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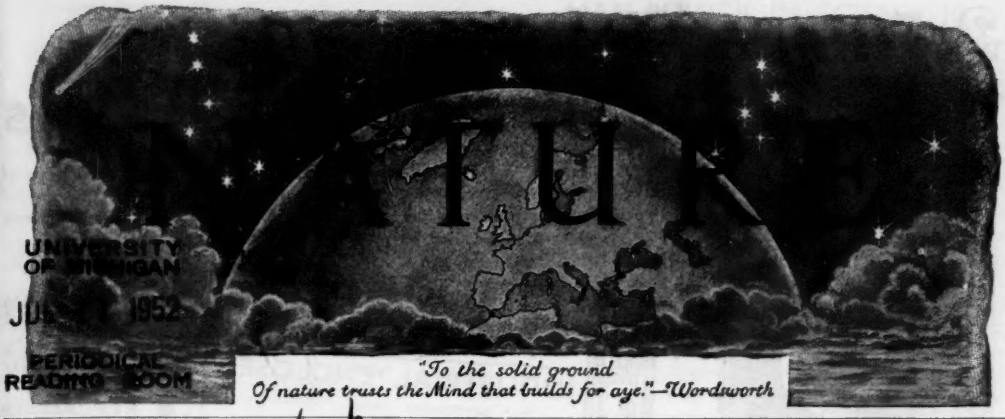

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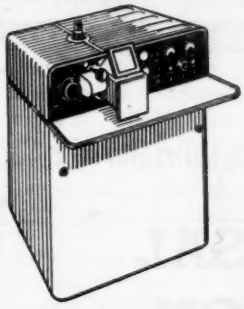

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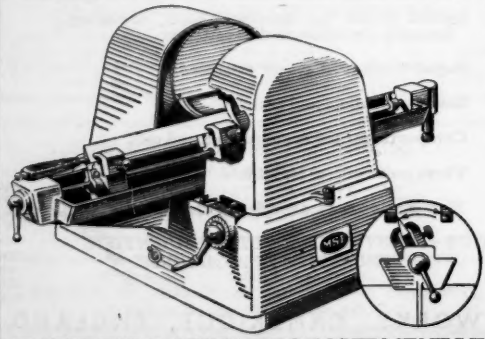

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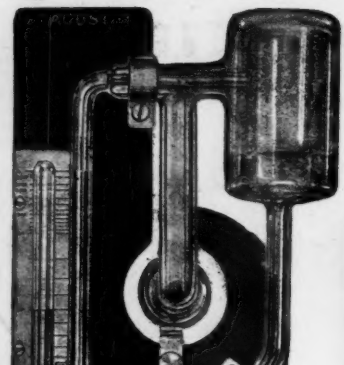

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MAN-POWER IN SCIENTIFIC AND TECHNICAL DEVELOPMENT

THE Advisory Council on Scientific Policy has from its formation in 1947 kept under review the demand for scientific man-power, and the measures being taken to meet that demand, as well as the appropriateness of the distribution of scientific man-power between defence and civil requirements. The Barlow Committee had reported in the previous year, and the more detailed reviews of the position with regard to particular categories of scientific workers made by the sub-committees of the Technical Personnel Committee of the Ministry of Labour only began to appear in 1949. Nevertheless, the first report of the Advisory Council devoted some space to consideration of this question, and it was considered at greater length in the Council's third report, in July 1950, particularly in the light of reports from the sub-committees covering the fields of chemistry, physics, geology, and civil, mechanical and electrical engineering.

The Advisory Council was then satisfied that, although we were approaching in Britain a point when the short-term demand for trained men of science might be fulfilled, continuing shortages were to be expected in the fields of chemistry and chemical engineering, and that the need for an increased supply of qualified men in general would persist. Afterwards, reports from sub-committees dealing with chemical engineering, biology and agriculture were published. In returning to this subject in its report for 1951, the Advisory Council referred particularly to the question of biologists, in view of a continuing shortage of most kinds of biological specialists, particularly for overseas posts and appointments under the research councils, in spite of the difficulty which more general botanists and zoologists were experiencing in finding employment. The Advisory Council then indicated its intention of returning to this question, and in the report for 1951–52, which has now appeared*, it makes the suggestion that the universities might usefully consider whether any changes could be devised in the general curriculum for biological studies, such as, for example, the introduction of more chemistry and physics, which would equip graduates in biology for a wider range of employment than is now open to them.

The whole of the fifth annual report of the Advisory Council is, however, devoted to a survey of the future demand for, and supply of, scientific man-power in general, and not merely of biologists. This survey was prepared by the Council's Standing Committee of Scientific Man-power, under the chairmanship of Prof. S. Zuckerman, which was appointed in December 1950. Besides being concerned with the supply of, and demand for, scientific workers during the current decade, the report also discusses the steps to be taken to rectify deficiencies in supply, and the quality of our scientific man-power and the steps to be taken

* Fifth Annual Report of the Advisory Council on Scientific Policy, 1951–1952. (Cmd. 8561.) Pp. iv+12. (London: H.M. Stationery Office, 1952.) 6d. net.

to improve that quality. The Committee commenced its task by considering the forecasts of the reports of the various sub-committees appointed by Lord Hankey's Technical Personnel Committee, particularly in the light of the demands of the rearmament programme and of such overseas developments as the Colombo Plan, to which the Advisory Council gave some attention in its fourth annual report and which is already causing concern to the various councils dealing with Colonial research. The dominant consideration which appears to have determined the policy advocated and such specific recommendations as are detailed in this report is the assumption that there is a direct relation between the efficiency or productivity of industry and the number or proportion of trained scientific men employed by industry.

That assumption possibly deserves rather more critical examination than it receives in this report; but the main argument that we need to increase both absolutely and relatively the number of scientific men in British industries is not invalidated by reservations on the observations regarding the proportion of high-grade to low-grade technical staff. Use of man-power with the greatest efficiency may indeed involve increased use of plant per man employed. Efficient use of highly trained staff involves, however, seeing that such staff is provided with adequate technical and clerical assistance; one of the chief weaknesses in this survey is the failure to give adequate attention to this question of making the most effective use of the highly skilled staff available.

However effective the measures taken to increase the output of scientific men prove in practice, there is likely to be a shortage of trained men and women for some years; and apart from this, industrial efficiency itself requires the utmost care to see that there is no waste of trained man-power on tasks that could be equally well performed by less highly trained workers. For this reason alone, the expansion of scientific man-power—and by this for the purpose of this survey we are to understand that technologists as well as scientific men are included—cannot be considered without reference to the supply of technicians and laboratory assistants. Plans to meet the demand for scientific workers based on the assumption adopted in this report that there will be a steady and rapid increase in our productivity cannot be formulated wisely without considerably more regard to the expansion of technical education than is given in this report. The Committee has, in fact, missed an opportunity of making clear the distinction between the technician and the scientist or technologist, and between technical and technological education, which has confused so much of the discussion of the expansion of technological education in recent years.

In regard to particular categories of scientific men, the Committee considers that special efforts should be made to increase the supply of chemists, chemical engineers, physicists and electrical and mechanical engineers, continuing shortages of whom are anticipated. At present the supply of geologists, civil engineers and metallurgists appears to be equal to the demand. The Committee does not, however, propose to make any quantitative estimates of the increased numbers which will be required in the future. Its inquiries have satisfied it that there will be useful employment for as many as are likely to be turned out in our present straitened circumstances, and that the demand is bound to continue to increase as long as Britain remains powerful in the affairs of the world.

Whether this will satisfy the universities and the technical colleges which are to provide the increased output of scientific men remains to be seen. It will be noted that the Advisory Council and its Committee refrain from giving any guidance about either the expansion or upgrading of technical colleges or the expansion of the scientific and technological departments of the universities. On the issue of a new technological university or expansion of existing university departments, although they "do not advocate any diminution in the importance of the humanities in our universities", by implication they are prepared to reconsider the balance of distribution between the arts and the science faculties. Many arts graduates, it is pointed out, are finding it difficult to obtain the employment they want, or for which they are fitted by their education, and there is no *a priori* reason why, in the context of the demands of the present age for men and women with a scientific training and outlook, the existing ratio between the faculties of arts and science and technology should be regarded as sacrosanct or inflexible.

Apart, however, from the question of the proportion between arts and science students in the universities, it has to be borne in mind that some appreciation of science and understanding of the scientific method and outlook is essential on the part of those destined for leadership in many, if not almost all, walks of life to-day. The universities cannot claim to be discharging their task of providing the nation with men and women fitted "to perform justly, skilfully and magnanimously all the offices both private and public of peace and war" unless some scientific training is given to all their students, whether they intend to follow an arts career or not. To the extent to which this is done, the absorption of arts students in industry should be facilitated, and at the same time the increasing trend towards the employment of scientific men in managerial and executive posts would be strengthened. Much remains to be done here in Britain. Lord Hankey's lecture last August on technical and scientific man-power emphasized the need for men competent to make the most effective use of large numbers of scientific men and technologists of different types; and although in the present report the Advisory Council makes no comment, little appears to have been done as yet to implement the recommendation of the Barlow Committee on Scientific Staff in 1943 regarding the transfer to the Administrative Class of the Civil Service of suitable scientific men possessing administrative ability.

The Advisory Council recognizes clearly enough that we are concerned here with the general education of the scientific man, as well as with his scientific

training. While it is satisfied that the scientific attainments of present-day science graduates are adequate, their education, especially in the technical colleges, is not sufficiently broad. It lends its support to the fairly general attempt now being made to correct excessive specialization and to see that graduates in science and technology are better equipped to deal imaginatively with the human issues which underlie many of the problems they will eventually encounter. This of itself should help to meet the demand, at present unsatisfied, for men with scientific training who possess both good academic qualifications and good personality.

There is no specific suggestion in this report, or from the Advisory Council itself, as to how this is to be done, nor as to how more men possessing the highest qualities of leadership and personality and at the same time equipped with a scientific training are to be encouraged to the front. Nor are any practical suggestions made regarding the employment of such men in the highest posts in industry and in the Civil Service, or for dealing with the loss of good scientific men to American industry—a consequence of the serious shortage of scientific workers which is also being encountered in the United States—which has been emphasized frequently in recent discussions on science and industry, such as that arranged by the Manchester Joint Research Council. The Advisory Council does recognize, however, that the number of men possessing high qualities of intellect and leadership is limited, and that a substantial increase in the number of those with such qualities who take up science can only be at the expense of other disciplines; and it points out that this is unlikely to happen without a change in the climate of opinion upon the prestige of science.

In so far as this report uses the term 'scientist' to include also the technologist, it is in line with much opinion that has found expression in the discussion on technological education as to the need for a higher status for the technologist, and for overcoming the notion that still lingers in some quarters that the pursuit of applied science is in any way inferior to that of pure or fundamental science. Science itself does not appear to attract, particularly in the public schools, as many boys of outstanding ability as is desirable in the national interest, and the report directs attention to certain influences which tend to counteract the attractions of science. Of these, the traditional emphasis on non-scientific subjects in the curriculum which most boys, in particular the abler boys, follow for the first four years is one, and lack of appreciation of the contribution that science makes to a liberal education another; and there still appears to be some aversion on the part of parents to the careers to which a scientific education is likely to lead, in particular to technical posts in industry. Here the headmasters of public schools and grammar schools might take useful action, both in advising pupils and in considering possible modifications of the curricula in those schools which have a classical tradition.

Generally speaking, it may be said that the report is more noteworthy for accurate diagnosis than for the clear prescription of remedies for the situation disclosed. As to the measures for increasing the supply of scientific and technical men, it believes that there is a substantial reserve of additional talent that could be trained; it does not accept the view that the three per cent of pupils at present proceeding to the universities includes the great majority of those remaining at school after the age of seventeen who are up to university standard. Further, the Committee found much evidence to support the view that there is a large potential reserve of university students among those who leave school before reaching that age.

The first step is to induce more of these to remain at school until nearly eighteen; but neither here, nor in dealing with the inadequate supply of good science teachers, are any positive proposals advanced. It is estimated that a considerable increase in the rate of recruitment, roughly from some 800–900 to some 1,200–1,300 a year in England and Wales, is needed to remedy present deficiencies and to provide for the increase in the number of grammar-school pupils. Although in its third report in 1950 the Advisory Council stressed the serious shortage in the supply of science teachers, here again no suggestions are made for dealing with the situation.

For all the accuracy of its diagnosis of the situation, which with minor qualifications will probably be generally accepted as sound, the report is thus disappointing. It is unfortunate that the Advisory Council has not seen fit to push further the inquiries which the Standing Committee may have felt diffident about pursuing, or lending the weight of its own authority and prestige to some concrete proposals. When, for example, the report refers to the ageing of the labour force as a reason for using man-power with the greatest efficiency, it does not proceed to examine the implications for technical and scientific man-power. Raising the age of retirement undoubtedly involves difficult administrative problems, if serious promotion blocks are not to be caused; but the use of the older professional men and women is an essential part of our scientific and technical problem. To extend the average professional life by, say, five years may not be a simple problem, but its implications should not have been dismissed from such a survey as this. Even if the Advisory Council has no practical proposals of its own to make for meeting the present situation, it could usefully have detailed in this report some of those that have been made elsewhere and commended them for examination. The problem has obvious short-term and long-term implications.

In the matter of higher technological education in Britain, a step forward is indicated by Lord Woolton's statement in the House of Lords on June 11 (see *Nature*, June 21, p. 1039). Thus although there is little on the subject in the report of the Advisory Council on Scientific Policy, it would seem that the Government has been provided with the necessary information. The detailed statement of the Government's intentions with regard to both higher technological education and technical education will be awaited with much interest.

LEONARDO THE ANATOMIST

Leonardo da Vinci on Movement of the Heart and Blood

By Dr. K. D. Keele. Pp. xviii+142+69 plates. (London: Harvey and Blythe, Ltd., 1952.) 84*s*. net.

AFTER an adventurous history of some hundred and twenty years the anatomical manuscripts of Leonardo da Vinci were acquired by Charles I, as Prince of Wales, when he was on a visit to Spain in 1623. They were brought to England and deposited in a "large and strong chest" in Windsor Castle. There they remained, and were completely forgotten for a further hundred and fifty years. At that time they consisted of 234 leaves and 779 drawings. Having at length been discovered by Mr. Dalton, the Royal Librarian, they were brought to the notice of William Hunter in 1784, who was deeply impressed by their importance and proposed to edit them for publication; but he died before his purpose could be accomplished. Another period of neglect followed, after which some of the drawings were mounted and exhibited in London under the supervision of the Prince Consort. Once more, however, the lid of the large and strong chest descended on these incomparable records, and it was only late in the nineteenth century that they began to appear in print. The small notebook on the "Flight of Birds" was partly reproduced in 1893, accompanied by a perfect facsimile, and the anatomical manuscripts were first printed in sixteen folio volumes in 1898 and 1901. A very beautiful edition of the anatomical drawings was published in Christiania (Oslo) during 1911–16 as six folio volumes. They cover the majority of Leonardo's anatomical studies from 1489 to his latest years; but the tragic fact remains that for more than three hundred and fifty years the outstanding pioneer researches of Leonardo played no part whatever in the history of anatomy.

An important issue raised by Leonardo's drawings is the extent to which they were based on human or animal material. Some from their very nature cannot be human; but in others the human attribution is inescapable, and a few combine both sources. He omits to name the types on which his dissections were made, and more often than not he fails even to describe his figures or to tell us what he had been taught by them. He does, in fact, claim to have dissected thirty human bodies, whereas Galen had never dissected, or claimed to have dissected, the human subject, and even Vesalius at times substituted animal for human anatomy when the appropriate material was not available. Such practice was justified on the assumption that, if the higher animals differed from man externally, they were all alike inside. Thus, in Leonardo's figure of the human skull and neck the details of the soft parts have been supplied from the dog; a rete mirabile from the ox has been added to the human brain, which is also provided with a set of injected ventricles taken apparently from the sheep; the studies of the heart were not based on man, but on the ox and sheep; a human fœtus finds itself in the uterus of the cow, and a large well-developed allantois obviously cannot have been human. Leonardo probably never saw the human placenta; nor could he convince himself that the blood circulated in the fœtus, but independently of that of the parent, although he himself had demonstrated the entirely independent nature of maternal and fœtal tissues in the cotyledonary placenta of the ox.

Did Leonardo discover the circulation of the blood? Dr. K. D. Keele rightly and emphatically answers this question in the negative. It would indeed be quite justifiable to add that Leonardo did not even come near to making the discovery; and yet more than a quarter of the time he devoted to anatomy was spent on the heart and its valves. He was not, in fact, convinced that the valves were necessary. He knew far more about the valves of the heart than Harvey; but the obligate part played by them in the circulation, which was so clear to Harvey, completely escaped him. It is truly astonishing that Leonardo should have seen so much and learnt so little. Perhaps he knew too much, and so a great discovery was obscured under a cloud of detail. In numerous passages and in a variety of ways he showed that he had no conception of the circulation as it was afterwards demonstrated by Harvey. In one respect, however, Leonardo must be defended. Dr. Keele and other commentators accuse him not only of believing, but also of actually figuring, the perforations of the ventricular septum. He certainly accepted the existence of these perforations, through which blood was supposed to pass from the right ventricle into the left as required by Galen; but he is not guilty of figuring what he could not possibly have seen. The transverse dashes that appear in the septum in Quad. I, 3 *R*, represent a method of shading, and indicate that the area enclosed by the outlines of the septum is solid matter and not a space. None of the dashes perforates the septum, and in one other figure they are longitudinal and not transverse. Further, the moderator band and other imperforate solid structures are shaded in the same way. The small figure of the septum in Quad. II, 3 *R*, and again in Feu. II, 3 *V*, also cannot be used to incriminate Leonardo on this charge. He saw the pits on the surface of the septum, and *assumed* that they were connected up by pores which he admits were invisible.

Dr. Keele has laboriously combed out from the confused mass of Leonardo's manuscripts all references and figures relating to the heart and blood vascular system. Commentary and English translations are also included. Students of Leonardo's anatomical recreations should be very grateful for such a book, since the originals are scattered and the facsimile reprints are almost unobtainable. The only complete set of the anatomical facsimiles in England, the Quaderni, the Fogli *A* and *B* and the Feuillets, is probably that in my possession. The ten chapters of Dr. Keele's work cover the life of Leonardo, his approach to anatomy, the anatomy and physiology of the systems of the body, the ancient authorities on the heart, Leonardo himself on the heart, blood vessels and vascular pathology, and a comprehensive assessment of his position in anatomical research. There is a good index. An important omission in the bibliography is that of the twenty-three volumes of the Feuillets. The book has been expensively printed and bound to form a handsome volume, which makes one regret all the more that many of the reproductions of Leonardo's drawings, such as Nos. 4, 6, 7, 8, 9, 10, 13, 24 and 60, are unhappily poor—in fact, so much so that some of them are worthless. No. 52 is a welcome exception, and there is no reason, despite the unfavourable condition of certain of the originals, why the others should not have been equally successful.

The following corrigenda may be noted. There is no evidence that Leonardo wrote a treatise on the anatomy of the horse: the two volumes of the Feuillets entitled "L'Anatomie du Cheval" contain no anatomy; his dissection of the leg in Quad. V, 22 *R* is his only illustration of the anatomy of the horse (pp. 5 and 35). For "bones" read "horns" and add the figure 3 before "ventricles" (p. 38, par. 5). For "dilation" read "dilatation" (p. 54 f.). Cordæ tendinæ and trabeculæ carnæ are incorrect spellings (p. 63 and Fig. 24 *passim*). There is no os cordis in the elephant (p. 57). As the figure includes both arteries and veins, the caption should read: "Tree of the Vessels" (pp. 99 and 101). F. J. COLE

WAVE-GUIDE ENGINEERING

Waveguide Handbook

Edited by Prof. N. Marcuvitz. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 10.) Pp. xiv+428. (London: McGraw-Hill Publishing Co., Ltd., 1951.) 64*s*.

IT is now fifty-five years since Lord Rayleigh showed theoretically that it should be possible to propagate two classes of electromagnetic wave inside perfectly conducting tubes of circular or rectangular cross-section; and he directed attention to the important feature that for each class there is a series of characteristic waveforms, with a limiting ('cut-off') frequency for each type, below which no free transmission occurs. It would perhaps appear a matter for some surprise that no further work, neither theoretical nor experimental—apart from that of Hondros and Debye, Zahn and Schriever on dielectric guides—was carried out for almost forty years after Rayleigh's discovery. The reason for this, however, lies in the fact that wave-guides are scarcely a practical means of transmission at frequencies less than about 1,000 Mc./s.; and it was only in the years just before the Second World War that reliable oscillators at sufficiently high frequencies became available, thus allowing the study of wave-guide transmission to be resumed. It was then shown, particularly by workers in the United States, that the attenuation which guided waves would suffer in imperfectly conducting tubes was low enough to make such wave-guides more efficient transmission lines at extremely high frequencies than the familiar parallel-wire or coaxial lines; also, the power-handling capacity of wave-guides is much superior to that of even the best coaxial line.

The development of high-power centimetre-wave radar systems during the War provided a great stimulus to the investigation of wave-guide circuits and components; such work was indeed a matter of urgency, for without the satisfactory extension of wave-guide techniques it would have been difficult, if not impossible, to realize the full advantages of radar at these very short wave-lengths. A number of books describing the war-time work and subsequent research on the characteristics of wave-guide circuits have already appeared, both in Great Britain and in the United States, but the volume here under review will probably be found more helpful to the radio engineer than any other yet written in view of its essentially practical approach to the subject.

The aim in the "Waveguide Handbook" is to present the salient features in the reformulation of microwave field problems as analogous network problems, and the subject principally treated is the class of electromagnetic boundary-value or diffraction phenomena descriptive of the scattering (or reflexion) properties of discontinuities in wave-guides; the reformulation in this way allows such properties to be calculated in a conventional manner from equivalent microwave networks composed of transmission lines and lumped-constant circuits. During the years 1942–46 a detailed examination of both the field and network aspects of microwave transmission was carried out at the Radiation Laboratory of the Massachusetts Institute of Technology, and J. Schwinger evolved an integral-equation formulation of field problems, the development of which resulted in a rigorous and general theory of microwave structures; and in this treatment conventional low-frequency electrical theory appears as a special case.

Although the main purpose of the book is to present the equivalent-circuit parameters for a large number of wave-guide arrangements—this forms the subject-matter of the later chapters—the first three chapters are devoted to a summary of the theoretical field and network considerations necessary for the derivation and use of the basic transmission-line and equivalent-circuit formalism. Chapter 1 deals with transmission lines, and Chapter 2 with the characteristics of the different modes of propagation in various kinds of wave-guide; the elements of network theory required for the analysis of the equivalent circuits of *N*-terminal microwave structures are outlined in Chapter 3. Generally, continuous wave-guides are used in practice in a manner such that the fields may be described by only a single propagating mode—the dominant mode; in contrast, the complete description of the fields near a discontinuity in the guide requires, in addition to the dominant mode, an infinity of non-propagating modes, but since the effect of the latter modes is restricted to the region of discontinuity, the fields in this region may be regarded as effectively 'lumped'. The equivalent circuits representative of the discontinuities, together with the transmission lines similarly representative of the continuous wave-guide sections, comprise a network which serves to describe the fields almost everywhere within the general wave-guide system.

The remaining chapters, 4–8, contain details of the equivalent-circuit parameters for a variety of *N*-terminal structures, the information being presented both analytically and graphically. In Chapter 4 two-terminal structures such as beyond cut-off and radiative wave-guide terminations are treated, while obstacle and aperture discontinuities in wave-guides, and gratings in free space, are among the four-terminal arrangements discussed in Chapter 5. Chapter 6 deals with six-terminal structures, and contains the equivalent-circuit parameters for a number of *E*- and *H*-plane *T*- and *Y*-junctions and bifurcations. Several systems involving eight terminals are described in Chapter 7. Finally, Chapter 8 contains the circuit description of various typical composite microwave structures such as dielectric-filled guides and thick apertures. In these last five chapters there are many tables and graphs containing a wealth of information which will be valuable to the engineer in the design of wave-guide systems.

"Waveguide Handbook" maintains the high standard set by previous volumes of the Radiation Laboratory Series, and it may certainly be recommended as a standard text of reference for all who are in need of guidance for the development of microwave equipment. J. A. SAXTON

TEXT-BOOK OF SPECTROCHEMICAL ANALYSIS

Principles and Practice of Spectrochemical Analysis
By Prof. Norman H. Nachtrieb. Pp. x+324. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 38*s*. 6*d*.

THE most rapid strides in the application of spectrographic methods to chemical analysis have taken place between 1930 and the end of the Second World War, and it has been noticeable that the production of good text-books on the subject has lagged behind this development to a considerable extent. The well-known and almost classical work of Brode has stood nearly alone for many years; recently, however, quite a number of authors have taken steps to remedy this deficiency. This work of Prof. N. H. Nachtrieb follows several recently published books on the subject and, of necessity, there must be some duplication of information in books dealing with different aspects of the same topic.

Prof. Nachtrieb has divided his treatment of the subject into two parts: "Principles", namely, theory and instrumentation, and "Practice", applications and technique. To deal with the subject-matter in this order, it can be stated that he has given a very full and comprehensive survey of the theory of the production and interpretation of spectra and the underlying fundamentals of the apparatus that is used for their recording; it is amply adequate for those for whom the book is intended, namely, analytical chemists. There may be some who would contend that it is even too comprehensive in this respect; for example, the theory of the photographic process could be considered ancillary to spectrographic procedure. Nevertheless, in a chapter on this topic the author emphasizes the value of photographic recording in providing a permanent record.

The instrumentation also receives extensive study, although, perhaps, the quantometer deserves a rather fuller description than it has received. A notable omission here, however, is the failure to describe any of the excellent and well-tried excitation sources that have been devised and are in use both in Great Britain and on the Continent of Europe. The name of Pfeilsticker, for example, who could be called the 'father' of controlled circuits, has not even been mentioned.

After a lucid exposition of the principles of spectrochemical analysis of such excellent quality, which occupies more than two hundred pages of the book, the hundred pages of practice come somewhat as an anticlimax. Prof. Nachtrieb has explained that it would be impossible to describe every technique, but he has confined himself far too much to American practice almost to the exclusion of methods from British and European laboratories. One exception is the Lundegårdh technique, but in his treatment of this method he has included details which have been out of date for some time, while omitting or only briefly noting more important matter. It is understandable perhaps that Prof. Nachtrieb's copper-spark method receives a detailed description, but other methods of performing similar operations should at least have received mention. It is very pleasing to see a final chapter on chemical preparation prior to a spectrographic finish; this chapter should receive the attention, in particular, of those who are in operational control of general analytical laboratories in which spectrographic methods are used.

A rather restricted bibliography is unfortunate, but is consequent upon the somewhat limited scope of the author's references to methods and techniques.

In general, this work has been written in a most readable style, though anyone not familiar with American idiom will need to read warily: for example, "in case" usually means "lest" in English, but it is used to mean "when" in this text; also "sawed" instead of "sawn" is harsh on British ears. There can be no criticism whatever of lack of diagrams and illustrations with which the book is copiously supplied, and which are all well executed. No more need be said of the binding, printing and quality of this book than that it is of the high standard that has come to be expected of the scientific literature of the United States.

In conclusion, this work should undoubtedly find a place in scientific libraries, if only for its excellent treatment of the theory of spectrochemical analysis in so far as it is needed by analytical chemists; but the somewhat limited scope of the practical side will exclude it from the category of a handbook for all spectrographers.

J. A. C. McClelland

THE VITAMINS

Vitamins
A Digest of Current Knowledge. By Dr. Leslie J. Harris. Pp. xii+244. (London: J. and A. Churchill, Ltd., 1951.) 15*s*. net.

NUTRITION, a relatively new science, necessarily rests on several of the older sciences such as chemistry, biochemistry, physiology and clinical medicine. The writer of a text-book in the field of nutrition always therefore faces the difficulty that his readers are likely to have experience in only one or two of these basic sciences. Dr. Leslie Harris addresses himself in this book to students and graduates in biochemistry, chemistry, pathology, dietetics and medicine. The failure of most books on nutrition to meet anything like these requirements makes a reviewer more than a little sceptical of an author's ability to justify such claims.

It can, however, be said at once that Dr. Harris succeeds brilliantly. In a book of just over two hundred small pages he has managed to give a clear outline of every aspect of the vitamins. The biochemist will find a concise and accurate description of reactions in which many of the vitamins are involved, reactions which he will often not find so well summarized elsewhere. At the same time, he will be able to follow with ease the clinical aspects of vitamin deficiency disease and will be especially helped by the admirable glossary of medical terms and the profuse illustrations of deficiency-states in animals and man. Similarly, those with little chemical training should have no difficulty in understanding the formulæ and equations liberally distributed through the book. Again, the research worker will be able to view his problems in true perspective and will be guided through the literature by the extensive and up-to-date lists of general and special references.

In recommending this book without hesitation to all who require a summary of the present knowledge of the vitamins, one must congratulate Dr. Harris on presenting such a readable, concise, accurate and well-documented account for such a wide variety of readers.

John Yudkin

Functional Mammalian Anatomy

(With Special Reference to the Cat). By Prof. William T. Taylor and Prof. Richard J. Weber. Pp. xi+575. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1951.) 55*s*. net.

THE authors of this zoology text-book have designed it "to approach the anatomy of the mammal, particularly the cat, in a dynamic way since it is most natural for a student studying the architectural elements of an animal body to know how they function". They have succeeded most admirably. One cannot but regret that the book, being North American in origin, necessarily deals essentially with the cat; but, even though it concentrates on the 'wrong' animal, there is no doubt that it could be of great value to any British student of chordate anatomy.

The volume is divided into fourteen chapters, of which the first is introductory and includes a brief anatomy of the fundamental tissues. The last is a manual for the regional dissection of the cat. The intervening 450 pages are devoted primarily to the anatomy, and secondarily to the function, of the integument, special senses, and the skeletal, muscular, nervous, blood vascular, respiratory, digestive, reproductive and endocrine systems. In addition, the urinary and lymphatic systems are treated in separate chapters. There is a brief appendix on mammalian classification.

"Functional Mammalian Anatomy" is both a text for the college easy chair and a manual for the laboratory bench, and it is a most useful antidote to the course given by the "sound man with the morphological approach". It does not neglect morphology, but it stresses more clearly than do most zoology text-books that the modern approach to anatomy is more than the careful separation and memorization of animal structures.

A. J. MARSHALL

Tempestuous Eden

By Ursula Venables. Pp. 239+28 plates. (London: Museum Press, Ltd., 1952.) 18*s*. net.

MRS. VENABLES went to the Shetland Islands as the wife of the ornithologist L. S. V. Venables, and the trend of the book is ornithological. Her style is pleasantly buoyant, and the information somewhat heterogeneously presented. They took a croft on the mainland of Shetland, not as crofters but as observers with a boat—in Orkney the native is a crofter with a boat, in Shetland he is a boatman with a croft; and the book tells of the simple but satisfying pleasures of the few years which they spent in their "Tempestuous Eden".

There is an interesting discussion of the human ecology, past and present: the men fish; the women work the land, which produces a subsistence from such basic products as potatoes, turnips and cabbage; hay and corn are grown for cattle, ponies, sheep and poultry; while the sea yields driftwood and a stock of dried fish for winter; and the moor provides a sure and inexpensive supply of peat. The unique Shetland cabbage is grown in stone-walled cisterns (plantie-crubs), and takes two years to mature; its seed is carefully preserved each year. But this independence is dying out, as are the industries inherited from Scandinavian forbears—wool-spinning and the knitting of shawls and jerseys, grinding with water-mills and kiln-drying the home-produced bere or barley for bread, curing mutton in windy unmortared stone huts (skeos), and drying cod on the foreshore.

Compared with the rest of Britain, the species of animal life are few, but interesting. Of the eight wild land-mammals inhabiting this windy, almost coverless main island, six are rodents (only one native), one is the stoat, and the eighth is the hedgehog, a surprisingly successful colonist introduced about 1860. The landrail, driven from most of Britain by the early and mechanical cutting of hay in which it nests, is still common in Shetland, where hay is cut late and with the scythe; but with the coming of early-rotation grasses and hay-machines it is now threatened there. The last two chapters describe visits to the remoter islands, Foula and Fair Isle, where the soil is good but harbours are poor, and the population is dwindling; and Out-Skerries, where the soil is extremely poor but the harbour is safe, and the population remains a strong fishing-community.

The appendixes include lists of breeding and non-breeding birds. The photographs are good; but the reader looks in vain for the convenience of a general map as end-paper.

R. M. LOCKLEY

Advanced Practical Physics for Students

By Dr. B. L. Worsnop and Prof. H. F. Flint. Ninth edition, revised and enlarged. Pp. vii+754+8 plates. (London: Methuen and Co., Ltd., 1951.) 30*s*.

IT is a real pleasure to welcome another edition of this well-known and excellent text-book of practical physics; for, since the work was first published in 1923, it has been a source of help and inspiration to both students and teachers.

Although the authors state that the course is for students who have completed the Intermediate stage and who are proceeding to a pass or honours degree, yet there are many sixth-form students in schools preparing for the Advanced and Scholarship levels of the General Certificate of Education who have used the book with advantage; no doubt many more will do so in the future. In this connexion it is perhaps a pity that in this latest edition the introductory chapter on the calculus has been omitted, though it must be admitted it has been replaced by a very useful chapter on accuracy of observations.

In addition to this change, the authors have undertaken a complete revision of the whole work, and have added chapters dealing with modern developments in physics, especially in the field of electronics. This feature should certainly widen the appeal of the book, to include students other than those immediately concerned with university examinations. The book is well illustrated, with many new diagrams, and no laboratory in any educational establishment should be without at least one copy.

The Theory and Practice of Wool Dyeing

By C. L. Bird. Second edition. Pp. 231+xvi+34 plates. (Bradford: Society of Dyers and Colourists, 1951.) 15*s*.

THE character of this book is evident from the fact that 'theory' occupies 22 pages out of 229, and that is all that the reader will find. The 'theory' is made as painless as possible by the relegation of thermodynamics to an appendix. Practice, on the other hand, is very adequately treated from the point of view of a technical art, with ample descriptions and illustrations of modern machinery.

S. M. NEALE

UNDERWATER OBSERVATION AND PHOTOGRAPHY OF FLOW PHENOMENA THROUGH GLASS PANELS IN A SHIP'S HULL

By J. W. FISHER
Royal Naval Scientific Service

THE observation of flow conditions about a submerged body moving at constant speed through water is greatly facilitated when the observer is stationary with respect to the body. The usual way of achieving this is to arrange for the water to flow past a stationary body in a water channel provided with glass viewing windows. Stream-lines can then be determined by injecting a suitable tracer (for example, small oil drops, small air bubbles or dye) upstream, while short threads attached to the surface of the body may be used for indicating points of flow separation, turbulence, etc.

A special case is the so-called 'cavitation tunnel', in which water continually recirculates in a closed tunnel and can be subjected to reduced pressure in order to initiate cavitation on the test body at speeds much below those which would be required at atmospheric pressure. Cavitation tunnels are used mainly for testing scale models of marine propellers with the object of deducing the behaviour of the full-size screws, which normally operate under cavitating conditions.

A water tunnel, even of the simpler non-cavitation type, capable of handling water-speeds up to 40 ft./sec. over a cross-section of even one square foot, is a piece of engineering equipment to be found in few institutions only. An alternative method has been developed, and used with success, in certain Admiralty experimental work. The idea is simply to attach the test body to a support below the hull of a ship, and observe it, while the ship is under way at the desired speed (the relative water speed can be measured by a Pitot-tube), through a glass panel let into the hull.

This arrangement, which may conveniently be termed a ship-borne flow observation channel, is illustrated, in a form already used, in Fig. 1. Essentially, it consists of a hollow steel cylinder with straight vertical sides and stream-lined horizontal section. This container has a flat bottom into which is fitted an oblong window made of $\frac{5}{8}$-in. thick armour plate glass. At a distance of 1 ft. below this, and supported from it by three hollow stream-lined vertical struts, is a shallow water-tight box, likewise stream-lined, and provided on its upper surface with an oblong light-diffusing window of similar size to the plate-glass window above. This chamber contains electronic flash discharge tubes and incandescent bulbs for either short-duration flash or continuous illumination. The lamps are supplied by cables passing down through the hollow struts.

This assembly can be raised or lowered through an aperture in the ship's bottom by means of a coffer dam arrangement. When in position for flow observation, the centre plane of the channel between the upper window and the lamp box is about 2 ft. below the ship's keel, in a position well forward in the hull.

The particular test body shown in the photograph is a length of stream-line strut, roughened to resemble a barnacle-coated structure. It is fixed to a vertical support traversing a water-tight gland at the front end of the oblong diffuser panel. An observer in the upper hollow compartment can view in silhouette, or photograph by short-duration flash, any cavitation which may originate on the strut surface. In another test, to find the frequency of eddy-shedding behind a strut, air was blown out from very small holes in the wall of the (hollow) strut, and the small bubbles photographed in the wake clearly depicted the periodic structure of the Kármán vortex street.

In order to provide a uniform background illumination for photography, two 'Sieflash' *S.F.*4 tubes mounted parallel to each other were used in series and supplied by a 250-volt power pack. The triggering induction coil was also accommodated in the same space close to the tubes, in order to keep the high-tension triggering circuit as short as possible. Working at night, the discharge of a 4-mf. condenser at 2,000 V. was adequate for photography of the bubble wake behind the strut, even with a camera aperture as low as *F*22. A Zeiss Contax camera provided with an 18-cm. focal-length *F*2·8 'Sonnar' lens with reflex attachment was found most suitable for the purpose.

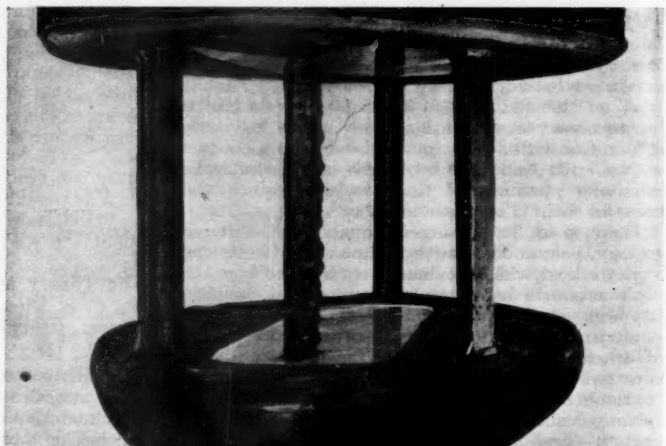

Fig. 1. General view of tunnel; specimen tube wrapped round by punched sheet

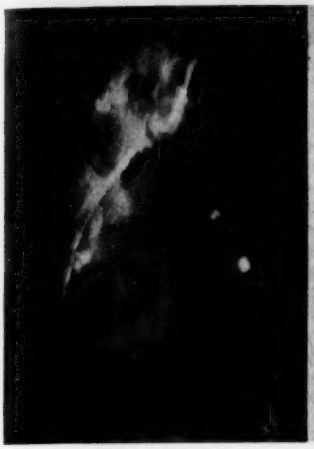

Fig. 2. 225 r.p.m.

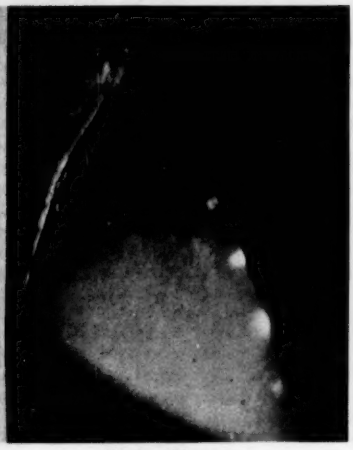

Fig. 3. 180 r.p.m.

A disadvantage of the gear in its present form is the time taken in withdrawing it by means of the cofferdam into the interior of the ship above the water-line, so that specimens can be changed or modified. It does, however, possess the great advantage that tests can be carried out in natural sea water and with no lateral tunnel walls to constrict the flow about the test body.

For many purposes the presence of the lower lamp box for silhouette illumination would not be essential, because the specimen could be illuminated by reflected light from an electronic flash tube mounted behind a separate glass port in the bottom of the upper container, in much the same way as described below for propeller photography.

A further, and more important, application of the direct-viewing technique through glass panels in the hull has been the observation and photography of cavitation on the ship's propellers.

Recently I have published elsewhere[1] a detailed report of this work, so a brief account of the main features only will be given here. The desirability of verifying by direct observation the extent to which the cavitation characteristics of a ship propeller can be related to those of its small-scale model in a cavitation tunnel will be evident. The model is usually run in de-aerated fresh water with a nearly uniform water flow over its disk area. The ship screw, on the other hand, works in air-saturated sea water and in a non-uniform flow caused both by the wake of the ship's hull and by the frequent near approach of the blade tips to the surface of the hull. Moreover, even if the model is run at the same mean slip and cavitation index (ratio of static to dynamic head) as the ship screw, the flow about the latter will usually correspond to a Reynolds's number ten to twenty times as great as that about the former. The nature of the water in which the model is run is known to influence cavitation, as has been shown by Edstrand in Sweden; the presence of dissolved air promotes the bubble type of cavitation, but is without much effect on the sheet variety. Wake variations may be simulated to some extent by introducing objects in the tunnel upstream of the screw.

What is believed to be the first direct visual comparison of cavitation zones on the actual ship propeller with those on a scale model in a cavitation tunnel was made in 1948, when successful short-duration flash photographs of the propellers on the frigate H.M.S. *Helmsdale* were taken. The ship was provided with two 8-in. diameter glass viewing ports of 1-in. thick glass and with 16-in. separation between centres. These ports were let in flush with the hull in a position slightly forward of the propeller blades. They could be covered on the inside by steel plates when not in use.

Adequate flash illumination for photography was secured by means of an *S.F.*2 'Sieflash' tube mounted in a reflector fitting over one of the glass ports while photographs were taken through the other. Two typical blade views were available by interchanging the functions of the ports. The flash was triggered by a hand-operated contact in series with another operated from the propeller shaft, thus ensuring that the blade to be photographed was always in the pre-selected position when the flash occurred.

Photographs were taken either with a Zeiss Contax camera, fitted with a wide angle (62°) 'Orthometer' *F*4·5, 3·5 cm. lens, or with a Leica fitted with an 'Elmar' *F*3·5, 3·5 cm. lens. An aperture of *F*4 was used with high-speed panchromatic Super XX film.

The discharge tube operated at 2,500 V. from a power pack fed from the ship's supply. A 4-mf. condenser discharge sufficed for visual observations, while a 50-mf. discharge was used for photography. Photographs had to be taken while cruising at night in order to avoid fogging the film, for the camera shutter was open before and after triggering the flash. The light path from port to propeller-blade was about 4 ft., and success depended entirely on the water being sufficiently clear to avoid fogging by back scatter. Sufficiently clear patches of water had often to be sought for far and wide.

Considerable distortion in the blade photographs is unavoidable, and to assist in measuring them up to define the limits of the cavitation zones at the different speeds, a series of equally spaced light abrasions were made around the edges of the blades by a file. These showed up brightly in the flash photographs somewhat like road reflectors and were of great assistance in the final mensuration of the pictures.

The propellers were 8 ft. 3 in. in diameter and 9 ft. 3 in. pitch and, at 275 r.p.m. (ship speed $\approx$ 18 knots), a zone of sheet and bubble cavitation extended over the peripheral half of the suction side of the blade. Figs. 2 and 3 show the appearance of the suction side of a blade at speeds of 225 and 180 r.p.m. respectively. The leading edge is to the left and the blade as shown is moving away from the observer. The white marks on the trailing edge are caused by the abrasions at 6-in. intervals referred to above. The zone of sheet cavitation peeling off from the leading edge is seen in each photograph. A zone of bubble cavitation which is just commencing in the 180 r.p.m. photograph is well established below the sheet cavitation in the 225 r.p.m. picture. Parts of the cavitating tip vortex spirals can also be made out to the right of the picture taken at 180 r.p.m.; they originate from the other two blades (not shown) of the propeller.

There was a close qualitative correspondence between the zones of sheet and bubble cavitation and those on a ¼-scale model of the propeller, provided the latter was run in aerated water in a cavitation tunnel at a speed rather higher than that nominally corresponding to the ship speed. The blades as photographed in the ship were, however, in positions where the hull wake exerts an important influence, which might account for some of the difference in equivalent speeds.

Although photographs are an invaluable adjunct, visual observation is perhaps even more important. As already mentioned, this can be made at night by using a stroboscopic flash synchronized by a propeller shaft contact, as is the practice in cavitation tunnels. There are, however, many positions on the blade surface which cannot be effectively illuminated by a flash issuing from any of the available ports. If, however, the observations are made in bright daylight, using a hand-operated variable-speed slit stroboscope, it is often possible to observe cavitation at these sites due to their being sufficiently well illuminated by the diffused sunlight below the hull.

Since these preliminary trials were made, observation ports have been fitted to other vessels, and a considerable amount of useful data is accumulating as a result. It has, for example, been found that the arms of an *A* bracket supporting the propeller shaft may in certain cases show heavy cavitation at high speeds; as is well known, this may be an important cause of structural erosion.

Another problem in which direct observation may prove helpful is that of the 'singing propeller'; it may, for example, be found that certain cases of excited blade vibration are associated with an intermittent tip-vortex cavitation, a combination of phenomena which I once observed when a model propeller in a tunnel was working at both very high slip and high cavitation index.

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[1] Fisher, J. W., *Trans. N.E. Coast Inst. Eng. and Shipbuilders*, **68**, p. 20; also *Engineering*, Dec. 7, 1951, p. 729.

THE CHANGING FLORA OF BRITAIN

By J. E. LOUSLEY

IT is perhaps persistence, rather than the changes in the British flora, which first impresses those who interest themselves in field botany. Remarks from older workers that plants have grown in the places where they know them since the days of their youth, and the realization that certain rarities are still to be found in the places whence they were recorded by early botanists, combine to give a false impression of permanence. The fact that local quantitative changes in the vegetation are going on constantly, and are sometimes not difficult to observe, is now well known owing to the work of ecologists over the past half-century. The qualitative changes in our flora generally are not so widely appreciated.

A conference arranged by the Botanical Society of the British Isles was planned to bring together the various approaches to the study of changes in the floristics of Britain. Held at the Royal Horticultural Society's New Hall, during April 4–5, under the title "The Changing Flora of Britain", the conference was attended by 270 members and guests. It was followed by a field meeting in Kent on April 6 for the study of species discussed in some of the papers.

The president of the Society, the Rev. Canon C. E. Raven, opened the proceedings with a paper on "The Significance of a Changing Flora". He instanced *Eryngium campestre* and *Veronica spicata* as species still to be found in the precise localities recorded by John Ray in the seventeenth century, and directed attention to the relatively small number of the very many aliens added to our lists since his time which have established themselves permanently. He pointed to the vitality and invasiveness of *Spartina townsendii*, like *Poa annua* and *Galeopsis tetrahit* which are likewise now regarded as of hybrid origin, and suggested that further investigation of examples of such amazing efficiency might demonstrate that fertile hybrids have played a not unimportant part in the process of evolution. "While the changes in our flora by invasion give rise to a number of fascinating ecological, physiological and chemical problems which deserve full investigation", Canon Raven pleaded for a wider and deeper study of the changes taking place in our flora by the extreme variability of critical groups and especially of *Rubus* and *Hieracium*. These, he said, present fascinating problems not only to the systematist but also to the general biologist. Botanists should make a greater contribution to the general study of science than has been the case in the past, and this conference, by bringing together so large and varied a group of botanists, might do something to facilitate this by bridging the gap that is always liable to open between the field-worker and the expert, the amateur and the professional.

The historical approach to the theme was introduced by a paper by Dr. H. Godwin (Botany School, Cambridge) on "British Vegetation in the Full-glacial and the Late-glacial Periods". After reviewing the British Late-glacial (between 10,000 and 15,000 years of age) and earlier Full-glacial deposits, and evidence for their correlation with stages of glaciation and with West European deposits, he discussed floristic lists of species identified from beds of these ages. Two species, *Silene cœlata* Reid and the less-satisfactory *Linus præcursor* Reid, from the Full-glacial, are no longer known as living plants. A number of arctic–alpine plants have become extinct in Britain in the Post-glacial period; but material of twenty-six out of a total of seventy-six in the present British Arctic–Alpine element (as listed by Matthews) has been found in the Full- and Late-glacial deposits. Their distribution in many instances was very much wider than their present range. Of Matthews's other phytogeographical categories there were representatives of the Alpine, Arctic–Subarctic, Northern Montane, Continental Northern (ten recorded for the Full-glacial and fifteen from the Late-glacial, out of a total of ninety-one), Continental, Oceanic Northern and some others. The very long list of ruderals or weeds must indicate the prevalence of open conditions, bare soil surfaces and freedom from competition; and it is evident that many weed species hitherto thought to be introductions to Britain by Neolithic and later agriculturists are of much older standing. An appropriate sequel to Dr. Godwin's paper was the demonstration by D. Walker and R. West (Cambridge) of material collected from Late-glacial deposits in the Lake District, and of the

characters by which they had succeeded in distinguishing the pollen of *Betula nana* from that of *B. pubescens*. Dr. E. Dahl (Oslo) compared the sub-fossil and present distributions of some Scandinavian alpine plants and showed that these could be explained by the estimated maximum summer temperatures, since very warm periods in summer are detrimental to the species involved. Dr. Ch. H. Andreas (University of Groningen) discussed glacial relics in the Netherlands, and particularly *Carex aquatilis*, of which the existence in the country in Pleistocene times has been confirmed by the discovery of material in deposits of the Würm-glacial and Late-glacial periods. In the latter case it was accompanied by the remains of many of the species which grow with it to-day.

"Natural Factors Contributing to a Change in our Flora" were reviewed by Prof. T. G. Tutin (University College, Leicester). He stated that the three main causes of qualitative change are evolution, climatic changes and the introduction or extinction of species. The main processes of evolution are: (1) the gradual differentiation of species through mutation and selection without change of chromosome number, producing in time what Valentine has called *g*-ecospecies. *Primula vulgaris*, *P. elatior* and *P. veris* show a comparatively late stage of this process, and *Melandrium rubrum* and *M. album* a somewhat earlier stage. (2) The process of doubling, quadrupling, and so on, of chromosomes producing polyploid series and giving rise to *a*-ecospecies in Valentine's terminology. *Spartina townsendii* is a well-known example. Apomixis enables hybrids, notably triploids and pentaploids, which would otherwise be sterile, to reproduce successfully and largely accounts for the great number of 'small' species in genera such as *Hieracium* and *Rubus*. (3) The process of aneuploidy, which entails the gain or loss of one or a few pairs of chromosomes and also gives rise to *a*-ecospecies. This is rarer; but in certain genera, and in particular *Carex*, it is commoner than polyploidy.

Prof. Tutin then turned to climatic changes and suggested that these were the primary cause of *Senecio paludosus* and *Trichophorum alpinum* becoming extinct. *Alisma gramineum* and *Scutellaria hastifolia* he thought had probably been introduced by natural agencies. Quantitative changes in our flora are seldom noticed except among rare plants or plants that were formerly rare—the main causes are changes in climate (and annual fluctuations in weather), and drastic changes in habitats due directly or indirectly to man. The dramatic spread of *Chamænerion angustifolium* and *Crepis taraxacifolia* was discussed. In conclusion, he suggested that the two most important natural factors producing changes in our flora are evolution and altering climate—both very powerful and far-reaching, but both slow-acting. There is a great need for more observations from amateurs to provide the essential basis for experiments to be made by professional botanists.

A valuable opportunity of comparing changes in our own flora with those which have taken place in a district just across the English Channel was provided by Dr. Paul Jovet (Muséum Nationale d'Histoire Naturelle, Paris), who spoke in French. Abbot Questier had left note-books recording his observations made daily during 1843–76 in Valois, and by comparing these with the records of contemporary botanists from 1924 until 1949 it was possible to give a more complete account of the modifications than has yet been attempted for any English district. Prof. A. R. Clapham (University of Sheffield) dealt with "Human Factors contributing to a Change in our Flora" by considering the distribution and habitats of five abundant and widely distributed species which are more or less confined in Britain to secondary man-made habitats. These are *Aegopodium podagraria*, *Chærophyllum temulum*, *Anthriscus vulgaris*, *Tanacetum vulgare* and *Tussilago farfara*. He suggested that some of these at least could be regarded as ancient inhabitants of Britain which had colonized river drift-lines, etc., and been available for spreading into clearings made in the forests by Neolithic man. They would be likely to attract attention as potential foods or medicines, and when their original homes had been destroyed or modified, wayside hedges remained as suitable habitats. Dr. E. Hughes (School of Agriculture, Cambridge) described possible human historical factors which seem to explain the present distribution of *Eriophorum latifolium* and other species in the Conway valley. Areas enclosed in the sixteenth century contain this cotton-grass, which is absent from those enclosed in the medieval period.

Dr. Maurice Burton (British Museum (Natural History)) discussed "The Zoologist's Approach to a Changing Flora". He said that zoologists are all aware of the dependence of animals on plants, either directly or indirectly; but they are very diffident about considering anything beyond the limits of their own subject. There is a big gulf between the work of zoologists and botanists, and he suggested that many zoological problems might be resolved if we knew more about the detailed dependence of animals upon the flora. R. D. Meikle (Royal Botanic Gardens, Kew) discussed the post-war additions to the British flora. Excluding micro-species, rediscoveries and aliens, there still remained four species of outstanding importance which added a new family and two new genera to the British list. *Diapensia lapponica* L. was noteworthy as having been discovered by an ornithologist to the astonishment of botanists, and *Kœnigia islandica* L. was one of the few non-critical British plants discovered in a herbarium: both are undoubtedly native on remote hills in Scotland. *Equisetum ramosissimum* Desf. in Lincolnshire may have arrived fairly recently by spores carried by the wind from the Continent; *Cerastium brachypetalum* Pers. on railway banks in Bedfordshire may be derived from native stocks elsewhere which have been passed over for the common *C. viscosum*.

The geographical approach to changes in our flora was considered by Dr. S. M. Walters (Botany School, Cambridge), Dr. J. Heslop-Harrison (University College, London) and Dr. A. Melderis (British Museum (Natural History)). Dr. Walters dealt with "The Continental Element in our Flora". He pointed out that the whole of our flora is of an oceanic type, as one might expect from our cool mild climate with no great extremes, and the so-called 'Continental' species are those which do not occur commonly in western Europe. For convenience three types of these 'Continental' species can be recognized: (*a*) the Continental Northern Element which includes species characteristic of the northern coniferous forest and also some, like *Viola rupestris* Schmidt and *Astragalus danicus* Retz., which are not woodland plants; (*b*) the Continental Element proper, of

species widespread in central Europe and extending into eastern Europe and Asia—such as *Veronica spicata*; and (*c*) the Continental Southern Element—species with a patchy and discontinuous distribution in western Europe. These grade from examples like *Carex humilis* Leyss., a typical hill-steppe species, to those like *Buxus sempervirens*, which is perhaps Sub-Mediterranean rather than Continental Southern. Dr. Walters pointed out that our 'Continental' species are generally plants demanding soils of high base status (particularly lime), most of them are intolerant of shade and unable to persist in the later stages of succession, and some show considerable ecotypic differentiation. Some of them are now absent from areas from which it is difficult to believe that they are excluded by present factors of climate or competition. He suggested that present distribution could be explained by changes in climate having altered the available habitats, and by clearances of forest in different parts of the country taking place at different times.

Dr. Heslop-Harrison's paper discussed "The North American and Lusitanian Elements in our Flora" as based on the lists of constituent species accepted by Praeger. He showed that the "North American" species are all aquatics or plants growing near lakes, and, after examining earlier explanations of their present distribution, suggested that they could have been brought to the British Isles from North America, via Greenland, by the migratory movements of birds such as the Greenland white-fronted goose, *Anser albifrons flavicornis*. The weight of evidence is now strongly against pre-glacial survival as an explanation of the present distribution of the Lusitanian species. It seems more likely that their present areas are the remains of former continuous ones and that the problem they present should not be considered separately from that of other southern species in the British flora. He suggested that their present marked discontinuities of range are to be attributed partly to submergence of former land surface, partly to area shrinkage in later periods of climatic deterioration, and partly to extermination through the appropriation of their habitats by hardier or better adapted species. The exhibit prepared by Dr. A. Melderis on "Some Parallels between British and Scandinavian Plants" compared the mountain floras on the basis of the world distribution of the constituent species.

The contributions made by alien species to changes in the British flora were the subject of several papers. Sir Edward Salisbury (director, Royal Botanic Gardens, Kew) introduced this aspect under the title of "A Changing Flora as shown in the Study of Weeds of Arable Land and Waste Places". He pointed out that recent work had increased the probability of the views he expressed twenty years ago concerning the evolution of plants of open habitats in relation to the vast morainic deposits at the end of the glacial epoch. The wide distribution of some of these species that appear to belong to no definite geographical component may well be an ancient feature. Human activities have provided sanctuaries for plants of open habitats; and for those which are found mainly in artificially created conditions it is largely a matter of guesswork whether they are to be regarded as native or not except in the cases where we have evidence of their introduction. He reviewed changes in weeds found in arable land, introductions from Europe and America and contrasts between the rate of spread of different introduced species, and he reminded the audience that "the British Flora is not an event but a process that is continuing both with respect to accretions and diminutions".

"The Recent Influx of Aliens into the British Flora" was considered by Mr. J. E. Lousley (general secretary, Botanical Society), who enumerated the known and suspected agencies by which plants are introduced. He stressed the changes in these sources due to variation in commerce and customs, and urged the need for closer study of the means of introduction. Opportunities for sampling the plants being brought in at docks, railway yards, canal wharves and rubbish tips, and the stages by which species became established in artificial habitats or naturalized in competition with the native flora were reviewed. *Thlaspi alliaceum*, *Ranunculus muricatus*, *Vulpia megalura*, *Rapistrum rugosum*, *Bunias orientalis*, *Tetragonolobus maritimus*, and *Acæna anserinifolia* were considered in some detail, and their history in Britain described. All fairly recent introductions, they were selected as forming a series, in the order given, showing decreasing dependence for their persistence on human activities. An exhibit of "Wool Aliens" by Dr. J. G. Dony (field secretary, Botanical Society) had special reference to those found in Bedfordshire during the past five years, with an analysis of the species found according to the countries where they are believed to be native. The spread of the North American *Epilobium adenocaulon* and the New Zealand *E. pedunculare* in Britain were illustrated respectively by Mr. G. M. Ash and Miss A. J. Davey (University College of North Wales, Bangor).

Trees and shrubs were discussed by Dr. E. F. Warburg (University of Oxford), Mr. A. D. Bradshaw (University College of North Wales, Bangor) and by Mr. C. D. Pigott and Dr. S. M. Walters (Botany School, Cambridge). Dr. Warburg pointed out that alien woody plants had been generally neglected in favour of herbaceous species, and that it was important that they should receive more attention than had been given them in the past. Trees and shrubs were introduced for forestry, for ornament, for fruits and for other purposes. Those introduced for ornament were responsible for the largest number of escaped and naturalized species; but field botanists seldom recorded them. One example he gave was *Rhododendron ponticum*, which was of considerable ecological importance, and yet the available data were insufficient to give its range or spread. Mr. Bradshaw outlined the ecological differences between *Crataegus oxyacanthoides* and *C. monogyna* and the distribution of hybrids between them. Mr. Pigott and Dr. Walters suggested that *Buxus sempervirens* had entered Britain in the boreal period, and that the dry sub-boreal period with Neolithic clearance of the woodlands had provided opportunities of secondary spread. In England place-names derived from the name of the tree followed the limestone ridges. They considered it native on steep slopes such as the one above the Mole at Box Hill and as scrub by ancient trackways; but in some places it had been planted in recent times.

An exhibit by Mr. D. E. Allen (University of Cambridge) on "The Changing Botanists of Britain" showed that the spread or decrease of many species would be likely to pass unnoticed in earlier days, when the main interest was in collecting specimens for the herbarium. The last paper read to the Conference was by Sir Arthur Tansley (chairman of the

Nature Conservancy) on "The Conservation of British Vegetation and Species". He described the work and organization of the Nature Conservancy, which is specially concerned with the scientific and practical importance of preserving as much as possible of our native flora and fauna. The central immediate object of the Conservancy is to establish a number of National Nature Reserves, of which six are now ready for 'declaration', on making which responsibility for the area is assumed. With the Beinn Eighe reserve in Wester Ross already declared, these make the Conservancy's total holdings to date 21,615 acres, and other reserves are in an advanced stage of negotiation. He outlined the plans for developing the scientific work of the Conservancy, which include the establishment of two research institutes, one in the north and the other in the south of England.

Canon Raven, in his concluding remarks, said that this had been a very memorable conference indeed and that the papers had opened up aspects of field botany which were new. Many suggestions had been made by the various speakers, and he hoped that the Society would develop some of these as projects for collective work involving country-wide studies. The papers which had been read and accounts of the exhibits would be published as a book with the same title as that of the conference.

MOUNTAINS AND GRAVITY*

By P. EVANS

Burmah Oil Company, Ltd., London

THE first laboratory measurements of the gravitational attraction between two bodies were made in 1797 by Cavendish, using the torsion balance. Much later, in a more direct method, an ordinary balance was employed, the scale pans being replaced by small equal spheres and a large mass of lead placed first under one sphere and then under the other. Both methods present experimental difficulties, but the force of attraction between two particles is now known with accuracy.

Even before the Cavendish experiments, attempts had been made to find the gravitational attraction of a large mountain mass. Measurements in the Andes seemed to be only partially successful, but an investigation near Schiehallion in Scotland in 1774 gave a value for the gravitational attraction which is reasonably near the truth. The deflexion of a plumb-line towards the mountain was measured, using as a reference point a star conveniently overhead.

Surveyors' observations made for the determination of latitude involve the same principle, and if the plumb-line is not truly vertical the latitude determination will be in error. Latitude measurements in the plains of India showed big discrepancies, and exactly a hundred years ago, in 1852, the Surveyor General of India wrote to a mathematician, Archdeacon Pratt, of Calcutta, directing his attention to the unsolved problem of reconciling these determinations of latitude. It soon appeared that the errors could be explained only if the plumb-bob was being deflected away from the Himalayas, instead of, as would be expected, towards them.

* Substance of a Friday Evening Discourse at the Royal Institution, delivered on May 9.

The possible explanation of this discovery led to much discussion, and many subsequent measurements of the deflexion of the vertical have been made. The problem can more conveniently be expressed in terms of variations in the earth's gravitational field, gravity being smaller near the mountains than would be expected. Measurements with modern instruments capable of detecting a change in the force of gravity as small as one part in a hundred million are much easier and quicker to make than are measurements of the deflexion of the plumb-bob.

In 1855 the Astronomer Royal, Sir George Airy, suggested that the visible crust of the earth is supported on a denser layer and that the extra mass of the mountains is balanced by light material extending down as roots into the denser layer: this goes far towards explaining the anomalous plumb-bob and gravity readings immediately south of the Himalayan range. In 1859 Pratt developed an alternative hypothesis. He supposed that the upper layer of the earth's crust had originally been of uniform density and thickness, without mountains or valleys or ocean deeps, and imagined that in the course of time the crust underwent vertical expansions and contractions. He considered that the material below the crust would prevent any downward expansion, so that where the crust expanded mountains were formed. It followed that beneath the mountains the crust must necessarily be composed of lighter material than is found beneath surrounding parts where there are no mountains. It is not always realized that Pratt's hypothesis was an attempt to explain mountain formation by simple vertical expansions of the earth's crust.

The Airy hypothesis of mountain roots received little attention; but his underlying notion of the mountains floating in a denser yielding material was taken up by Dutton, who, in giving more precision to the idea, coined the term isostasy. Later, Hayford and Bowie firmly welded the isostatic idea to the Pratt hypothesis; they found from a study of data, mostly referring to America, that if allowance was made for the compensating effect of the supposed lighter material beneath the mountains, computed strictly in accordance with the Pratt hypothesis, many observed values of gravity were brought very nearly into agreement with calculated values, the depth at which compensation is complete being taken at about a hundred kilometres. These and subsequent calculations utilizing numerous gravity determinations from different continents have shown that, when large surfaces of the earth are taken as a unit, there is in many cases a fairly close approach to the distribution of masses required by isostatic theory. It became generally supposed that the Indian gravity evidence, as well as the American evidence examined by Hayford and Bowie, supports the Pratt conception of isostasy: that is, the earth's crust was supposed to be made up of a set of vertical columns, each one uniform throughout, each differing in density from its neighbours, and each having its density exactly related to the present relief of the surface, regardless of what that relief might have been in past ages. Geologists have long known that this does not represent a possible condition of the earth's crust, yet the Pratt–Hayford–Bowie conception of isostatic compensation of hills and mountains remains the accepted basis of routine calculations in the computation of gravity anomalies. Although the Pratt hypothesis can be defended as a mathematical convenience which does not pretend to

have any close resemblance to reality, it was not put forward as such, but as a theory of the origin of mountains.

It is only in recent years that the Airy hypothesis has received attention. One reason for the long life of the impossible Pratt–Hayford–Bowie hypothesis seems to be that the actual effects on the surface are not as greatly different with the different hypotheses as might be expected, since the centres of gravity of the supposed compensating masses must lie at a very great depth beneath the surface. But a more important reason is probably the failure of geologists to take an active interest in the development of the idea of isostasy, leaving it to mathematicians, who seem not to have been encouraged to find out whether their postulates were geologically possible.

Although geodetic computations (designed to ascertain how nearly the earth's crust is in isostatic equilibrium) appeared to show that gravity anomalies could largely be accounted for by the postulated compensating masses beneath the mountains, some relatively small and a few fairly large anomalies remained after applying the correction for isostatic compensation. It was, however, widely assumed that these could be accounted for by variations in the surface rocks, as, for example, the contrast between light alluvial sediments and dense lava flows. None of the geodetic calculations had made any allowance for this factor, in spite of the protests of the American geologists G. K. Gilbert and David White. Later, R. T. Chamberlin, E. A. Glennie and others were not satisfied that allowance for local geology would get rid of the gravity anomalies, and the matter was clinched by the extensive gravity surveys of Vening Meinesz and others which revealed very big anomalies clearly defying any such simple explanation.

Until recently, no attempt had been made to evaluate the gravitational effects of surface rocks in a large area where a great thickness of sediments is present, but this has been done in an extensive gravity survey (carried out by the Burmah Oil Co., Ltd., and associated companies) of parts of India and Burma, the results of which have been published by the Geological Society of London[1]. After an investigation into the probable effective densities of the relatively light Tertiary sediments of this region, appropriate corrections were computed by a method suggested by E. A. Glennie, and for the first time a gravity map of a large area was produced in which allowance had been made for local geological effects. Very large anomalies remained, and even when further corrections were made to allow for the hypothetical isostatic compensation, there were still large unexplained residual effects. This work strongly supported the contention of Glennie and others that, contrary to general belief, the gravity evidence from India taken as a whole does *not* support any hypothesis that the region is in isostatic equilibrium. It also demonstrated the possible magnitude of the effects arising from surface geology.

After the removal of these effects due to the known geological structures, the gravity irregularities attributable solely to deep-seated causes were found to have a distribution closely related to the principal lines of earth movement. The hills between Assam and Burma coincide closely with a belt of intensely folded strata, and this is marked by pronounced minimum values of gravity. To the east of this, a gravity maximum corresponds closely with a line along which volcanic activity has taken place in the not very distant past. The work in India and Burma links up closely with the large gravity anomalies found by Vening Meinesz in the Netherlands East Indies.

The Ganges–Brahmaputra, Irrawaddy, Mekong and Red River deltas all show gravity maxima if allowance is made for the effects of the light sediments composing these deltas. The Indus delta has been found also to be an area of relatively high gravity, and so have the Nile and Mississippi deltas.

Although there is no unique solution of a gravity picture, the magnitude of the broad regional gravity anomalies makes it possible to set limits to the nature of the masses responsible for the anomalous gravity values in south-east Asia. Seismic records have shown that an approximate representation of the earth's crust can be obtained by assuming three layers of increasing density, and it is clear that the excess of light material in the areas of relatively low gravity is due to the thickening of the upper layers at the expense of the lower ones.

These various recent investigations of gravity anomalies have shown: first, that the basic assumptions of the Pratt–Hayford–Bowie hypothesis are quite untenable; secondly, that allowance must be made for the effects of surface geology; and thirdly, that there are large areas of the earth's crust, particularly those where there has been recent mountain building, which are not in isostatic equilibrium.

It follows, then, that a device employed as a routine procedure by scientific workers concerned especially with measurements of the earth's crust is founded on a hypothesis which other scientific workers concerned especially with the structure of the earth's crust know to be wrong, and it is desirable to inquire why there should be this contradiction. It seems fair to say that the geologists have been at fault in allowing the mathematicians to develop the idea of isostasy in a manner which has been largely unprofitable—a result of lack of co-operation between groups of scientific workers of admittedly different temperaments. It is to be emphasized that, where a wide field of inquiry includes several separate compartments of science, progress will not be possible unless there is a partnership between men of quite different disciplines, and no fear of incompatibility of temperament between partners should be allowed to stand in the way of co-operation.

[1] Evans, P., and Crompton, W., "Geological Factors in Gravity Interpretation", *Quart. J. Geol. Soc.*, **102**, 211 (1946), which includes references to the authors mentioned above.

OBITUARIES

Mr. R. E. Enthoven, C.I.E.

Reginald Edward Enthoven, who died on May 21, had had a distinguished career in India both as a Civil servant and as an anthropologist. Educated at Wellington College and New College, Oxford, he entered the Indian Civil Service in 1887 when he was barely eighteen. He was posted to the Bombay Presidency, where most of his service was spent, though he acted during 1912–15 as Secretary to the Government of India in the Department of Commerce and Industry.

Quite early in his career, Enthoven published a monograph on the cotton fabrics of Bombay, and his interest in the sociological aspects of Indian life was shown very clearly in his "Report on the Census of Bombay, 1901". His work as census superintendent for that Presidency had been much impeded by

famine and plague; but it was no doubt Enthoven's work on that census that led to his appointment as honorary superintendent of ethnography in Bombay, in which capacity he had charge of the ethnographical survey of the Presidency. This culminated in 1920 in the publication of his three volumes on "The Tribes and Castes of Bombay", a survey for which a small annual financial provision was made when the work started. This provision, however, was withdrawn in 1909 before the work was half done, and the task was carried to completion by the voluntary labours of Enthoven himself with such assistance as he could obtain without expenditure of funds. Crooke's "Tribes and Castes of the N.W. Provinces and Oudh", Risley's, Russell's, and Rose's similar volumes on Bengal, the Central Provinces, and the Punjab and North-West Frontier Province, and Thurston's "Castes and Tribes of Southern India", together with Enthoven's volumes on Bombay, all alike instigated in the first instance by Nesfield, Ibbetson and Risley, form the main corpus of information on Indian castes. But Enthoven, like Crooke and Thurston, went further and published in 1924 his volume on "The Folklore of Bombay", a very valuable continuation of the earlier work in the same field of Sir James Campbell, and a most important companion to the works of Crooke and Thurston. His interest in this aspect of Indian life had perhaps been kindled, or at any rate fed in him by an incident early in his career in which, as a junior magistrate, he was called upon to investigate the unnatural death of a girl as the result of an attempt to drive an evil spirit out of her by jumping on her and thrashing her.

In 1916 Enthoven got leave from India to take up a war-time appointment in the Board of Trade, where he became eventually controller of the department of import restrictions. He returned to India after the First World War, but retired in 1920 and became an underwriter at Lloyds. He was awarded the C.I.E. in 1920, and was also a Commander of the Order of Leopold II; but it is for his work on Indian ethnography and folk-lore that he will be best remembered.

J. H. HUTTON

Dr. A. Lasnitzki

DR. ARTHUR LASNITZKI, who died suddenly at Birmingham on April 18 at the age of fifty-six, was born in Lauenburg, Germany. After completing his early education he studied medicine with special training in chemistry, physics and mathematics at the Universities of Berlin and Bonn. His predominant interests were in the scientific aspects of physiology and biochemistry.

During 1921–25 Lasnitzki worked at the Universities of Rostock and Berlin, where he carried out investigations on the biological action of hydrogen acceptors and the nature of heterogenic precipitins. His wide knowledge of chemistry and physics proved of great value in his studies on the surface tension of tissue fluids and the absorptive capacity of hydrophyllic colloids. He also elaborated a manometric method for the determination of lipase in body fluids and tissues.

During the past twenty-five years he devoted his great abilities to the problem of cancer and the intricate nature of the cancer cell. From 1926 until 1933 he worked as head of the Biochemical Laboratory of the Cancer Research Institute, University of Berlin, where he carried out and directed studies on the metabolism and the influence of electrolytes on adult, embryonic and tumour tissues. In 1933, due to the Nazi oppression, Lasnitzki was dismissed from his post but found refuge at the University of Manchester, where he spent the next five years, working untiringly and in difficult circumstances. In collaboration with A. K. Brewer, of Washington, he was among the earliest to investigate the occurrence of isotopic and radioactive elements in tumour and normal tissues, in particular the significance of the shift of the isotopic potassium in neoplastic growth.

For the past fourteen years Dr. Lasnitzki had worked at the Medical School, Birmingham, continuing his biochemical studies and examining some aspects of carcinogenesis, particularly the histological changes in the lymph nodes of animals induced by carcinogenic hydrocarbons and extracts of cancer tissues. Much of this work is still unpublished, and some he had been unable to complete.

Dr. Lasnitzki always extended a warm-hearted generosity towards colleagues and friends who sought his help or advice. He was keenly interested in meetings of scientific societies and found great satisfaction in exchanging ideas with others on these occasions. He had a sensitive disposition, and occupied his mind with science almost to the exclusion of other sides of life. It was his high intellectual integrity which made him suffer intensely when he witnessed the decline of principles and standards he held dear. Though in failing health for several months, he had been drawing together results of his researches only a few hours before his death, with the meticulous care which characterized all his work.

He is survived by his widow, who has collaborated with him in a number of his researches.

Sir Algernon Aspinall, K.C.M.G., C.B.E.

SIR ALGERNON ASPINALL, secretary of the West India Committee for forty years, until his retirement in 1938, and of the Imperial College of Tropical Agriculture, British West Indies, from its foundation until 1940, recently died at the age of eighty. Himself not a man of science—he was called to the Bar in 1897—Sir Algernon was one of those who did much to promote the cause of science in its application to the problems of tropical agriculture. His work in connexion with West Indian agriculture, in particular with sugar and cocoa, and in relation to the founding and management of the affairs of the Imperial College of Tropical Agriculture—the recognized centre for postgraduate training for the Colonial Agricultural Service—will long be remembered with gratitude and respect by those who undertook the actual work on the spot. His keen personal interest in, and appreciation of, their efforts and the warmth of his welcome on their return to London were palpable factors in building up the tradition of sound scientific endeavour in the tropics. Sir Algernon is well known as the author of several guide and other books on the West Indies. These reflect the man: they are learned, friendly, witty and urbane.

WE regret to announce the following deaths:

Prof. H. A. D. Neville, C.B.E., emeritus professor of agricultural chemistry in the University of Reading, on June 17, aged seventy-one.

Sir Lindsay Scott, K.B.E., president during 1946–50 of the Prehistoric Society, on June 17, aged fifty-nine.

NEWS and VIEWS

Directorship of Colonial Products Research : Sir John Simonsen, F.R.S.

Sir John Simonsen is to retire at the end of this year from the post of director of Colonial Products Research, which he has held since the setting up of the Colonial Products Research Council in 1943. He took to the new office a wide experience derived from his previous distinguished service in India and as professor of chemistry at Bangor ; and has organized a system in which fundamental and applied studies on the properties of Colonial raw materials are now engaging the attention of an array of outstanding specialists in university laboratories and elsewhere. Research encouraged and supported by the Council includes such diverse subjects as attempts to find new uses for clove oil, fundamental studies of carbohydrates, the utilization of timbers, properties of vegetable oils and investigation of plants of possible medicinal or insecticidal value. With intimate knowledge of the chemical problems involved and of the workers best qualified to solve them, Sir John has found a good home for each of these and many other projects. Much of the work initiated is of necessity of a long-term nature, but some has already proved of practical value ; and at that stage his close contacts with industry have ensured utilization of the results. One of his keenest interests has been in the inception and progress of the Colonial Microbiological Research Institute in Trinidad, which was opened in 1948. He has also been closely concerned with the development of sugar technology research at the Imperial College of Tropical Agriculture, and has paid several visits to the West Indies in connexion with the work of both institutions. Besides serving on many bodies concerned with Colonial research, Sir John Simonsen was secretary of the Chemical Society during 1945–49. He has been a member of the Agricultural Research Council (1944–49) and continues to serve on several of its committees.

Dr. R. A. E. Galley

Dr. R. A. E. Galley, who has been appointed to succeed Sir John Simonsen, graduated at the Imperial College of Science and Technology in 1930 and took the Ph.D. of the University of London in 1932. He was then successively with the Wool Industries Research Association, where he discovered and developed a process for rendering wool unshrinkable, chemist in the War Department and lecturer in chemistry in the Sir John Cass College, London. During the War he was chief chemist in charge of inspection at the Ministry of Supply Chemical Defence Factories, and then for a short time head of the Research and Development Department at H.M. Norfolk Flax Establishment. In 1946 Dr. Galley was appointed secretary of the Inter-Departmental Insecticide Committees, which were attached to the Agricultural Research Council. In this post he was responsible for the co-ordination of research and development on insecticides in the United Kingdom and Colonies, and for maintenance of liaison with the Dominions and the United States in the same field, covering medical and industrial as well as agricultural aspects of the use of insecticides. He visited the United States in connexion with this work in 1948, and in the following year was a member of a technical mission to West Africa in connexion with the swollen shoot disease of cacao. Dr. Galley is a member of the World Health Organization Expert Committee on Insecticides and acted as chairman at the second and fourth sessions. Last year he was seconded to the secretariat of the Advisory Council on Scientific Policy in the Office of the Lord President of the Council. Dr. Galley has thus had varied experience in several branches of applied chemistry and in co-ordination services.

Botany at Liverpool : Prof. John McLean Thompson

Prof. J. McLean Thompson is retiring from the chair of botany in the University of Liverpool on September 30, and is to be succeeded by Prof. N. A. Burgess, of the University of Sydney (*Nature*, 158, 659 ; 1946). As a student of Bower at the University of Glasgow in the first decade of this century, Prof. J. McLean Thompson came into botany in the heyday of comparative morphology and was closely associated with some of its most able exponents. His early researches, inspired by Bower's phylogenetic studies of the ferns, were concerned with the morphology of various rare and primitive ferns, these affording a testing ground for the criteria of comparison which had been elaborated. His reconstructions of fern steles have long had their place in standard texts, while his studies of sporangial development gave an indication of the exactitude and artistry which were to be the hall-marks of all his morphological work. In due course the fern studies gave way to what was to become his life-work—the study of floral morphology in terms of development, causality and evolutionary relationships. This may best be described as a courageous one-man expedition into a vast and varied territory. His initial investigations of staminal zygomorphy in *Couroupita* and *Napoleona* were the models on which many later studies were to be based. He approached the problems of floral morphology with an open mind, with no preconceptions as to the existence of established categories of parts, but simply to ascertain how flowers develop and what kinds of interpretations and comparisons are feasible and legitimate.

On his appointment to the chair of botany in the University of Liverpool in 1921 these floral studies were pursued with vigour, the collections of many visits to tropical and subtropical regions being worked up. These studies have, on the whole, related to orders where a not inconsiderable measure of complexity is the rule ; but his elucidations of even the most complex of configurations and his supremely elegant, detailed illustrations constitute a mine of information to which future botanists, interested in these problems, will often return. The data of his studies of advances in sterility and in gigantism, and supporting his theories of the leguminous strobilus and the Scitaminean flower, will long stand as models of what the morphologist has been able to contribute in this field of research. In the more recent period, Prof. Thompson has been occupied with the very complex and enigmatic phenomenon of cauliflory. In these studies he has shown the extraordinary morphogenetic potentiality and diversity of the bud-forming regions of the trunks of various woody species. Again, the details of development are of a very high order of complexity ; and while it cannot be said that the underlying causal factors have been ascertained, his demonstrations indicate what the problems are and where the solutions are to be sought. The hope may perhaps be expressed that in his retirement Prof. Thompson will bring together in

book form his long and unique experience of the problems of floral morphology.

Radioactive Contamination in Laboratories

CONTAMINATION of the person or of laboratory areas and equipment is a problem of fundamental importance to those working with radioactive isotopes. Constant vigilance must be maintained not only to prevent contamination but also to contain its spread. Though the primary concern in this regard must always be the protection of workers in the area from health hazards of potentially dangerous radiations, the maintenance of uncontaminated equipment and laboratories is also important if precise and reliable results are to be obtained. Handbook 48 of the United States National Bureau of Standards, entitled "Control and Removal of Radioactive Contamination in Laboratories" (pp. 24; Washington, D.C.: Government Printing Office, 1952; 15 cents), is, in spite of the considerable uncertainty regarding permissible radiation exposure-levels, a very useful handbook, and if the precautions listed are carefully carried out should greatly assist in minimizing the possibility of accidents involving radioactivity and the effects of such accidents as may occur. The handbook stresses that only persons who are properly instructed in procedures which will make their operations safe for themselves and others should be permitted to work with radioactive materials. This is particularly sound advice now that radioactive isotopes are in increasing use by industry, the medical profession and industrial and research laboratories. Permissible levels of contamination, in addition to decontamination procedures for the skin, clothing and bedding, laboratory tools and glassware, and specific materials used as surfaces of floors, work benches, hoods, etc., are dealt with in separate sections of the handbook. Emergency procedures in such cases as the outbreak of fire or a major spill of a radioactive solution are outlined, as well as general safety precautions. An appendix to the handbook in which decontaminating detergents and wetting agents are listed may be useful to chemists and United States citizens familiar with the trade names; but to the public generally the footnote "Most of the common household detergents, such as 'Tide', 'Dreft', etc., have been used successfully" is far more illuminating.

Calendar Reform

AT a recent meeting at the House of Lords, called by Mr. J. Avery Joyce and presided over by Lord Merthyr, the British Section of the World Calendar Association, Inc., of New York, was formed, there being no similar body existing in Great Britain since the War. The aim of the Association is to introduce a new calendar on a world-wide scale, having a number of business and administrative advantages and removing some of the defects of the existing calendar. It is recognized that the adoption, if at all, must come through an international organization, the United Nations being the most appropriate; Unesco is already in favour of the reforms proposed. Many hundreds of modifications of the existing calendar have been proposed and examined from time to time; that proposed by the World Calendar Association makes all the quarters equal and all begin on a Sunday. Months all have the same number of working days, but actually have 31, 30 and 30 days in each quarter. All anniversaries fall on the same days of the week. The months actually begin on Sunday, Wednesday and Friday to achieve the maximum benefit to business and administrative statistics. It follows that the proposed calendar is perpetual. The odd day in the year is taken as a public holiday before New Year's Day and is not counted. Likewise in leap years there would be an uncounted day in the summer. Correspondence for the British Section of the World Calendar Association should be addressed to 20 Buckingham Street, London, W.C.2.

The Buffalo

THE American bison or buffalo was once the most abundant hoofed animal in North America. It ranged from Pennsylvania to Oregon and from Mexico far into Canada in almost astronomical numbers. The native Indians depended on the animal for food and shelter, and their bows and arrows did not diminish its numbers. With the coming of the white man the buffalo was slaughtered for meat and sport and target practice, as well as to clear the plains for cattle. As settlers opened up the western prairies, the buffalo rapidly diminished in numbers. The last great herd was split in two when the first trans-continental railroad was completed, and soon it seemed that the buffalo was becoming extinct. In 1889 a census showed that, of the estimated original sixty million buffalo, there remained in the United States only 541. As a result of action by the New York Zoological Society, the American Bison Society and the United States Government, nucleus herds were established and protection was enforced. To-day the herd has been built up to 8,800 animals, and there is now hope that this fine animal may considerably increase in numbers ("The Unvanquished Buffalo", by Henry H. Collins, jun., Blue Heron Press).

Beit Memorial Fellowships for Medical Research

THE following elections to Beit Memorial fellowships have recently been made for medical research in particular fields at the places shown. *Fourth-Year Fellowship* (£700 *a year*): Dr. B. Cinader (formation of multiple antibodies to a single antigen and their properties), Lister Institute of Preventive Medicine, London. *Junior Fellowships* (£600 *a year*): A. G. Baikie (the place of biliverdin in hæmoglobin catabolism in man and laboratory animals), Department of Medicine, University and Royal Infirmary, Glasgow; K. Krnjevic (behaviour of nerve trunks), Physiology Laboratory, University of Edinburgh; Dr. L. Lorand (the constitution and function of 'fibrino-peptide' and isolation and characterization of the 'fibrin-stabilizing factor'), Lister Institute of Preventive Medicine, London; R. M. S. Smellie (biosynthesis and function of the nucleic acids in animal tissues), Biochemistry Department, University of Glasgow; and Dr. Winifred M. Watkins (biochemical studies in the field of the human blood groups), Lister Institute of Preventive Medicine, London.

1851 Exhibition Awards for 1952

THE Royal Commission for the Exhibition of 1851 has announced the award of senior studentships for 1952, worth £600-650 a year for two years. The four recipients, who have all elected to work at the University of Cambridge, will be doing research as follows: Dr. J. B. Armitage (Manchester), organic chemistry; R. L. Martin (Melbourne and Cambridge), inorganic chemistry; K. F. Smith (Cambridge), nuclear physics; and Dr. D. M. Vowles (Bristol and Oxford), zoology.

International Geological Congress

The nineteenth session of the International Geological Congress will be held in Algiers during September 8–15. Among the subjects for discussion are the subdivision and correlation of the Pre-Cambrian rocks; the Palæozoic strata of North Africa; the mechanics of rock-deformation; submarine topography and sedimentation; fossil man; the origin of vein-rocks; modern and ancient deserts; the hydrogeology of arid and sub-arid regions; applied geophysics; the genesis of iron ores and of phosphate deposits; and the oil-fields of the Mediterranean and Middle East. During the session there will also be meetings of the Association of African Geological Surveys, the International Paleontological Union, and the International Committee for the Study of Clays; and the Society of Economic Geologists will hold a special reunion. The Council of the Congress will discuss the question of forming an International Union of Geology. Draft statutes for an International Association of Sedimentology will also be considered. An extensive programme of geological excursions has been arranged, lasting in all from August 24 to October 28. It includes two series of long excursions through Tunisia, Algeria and Morocco—one series before and one immediately after the sessional meetings; a series of short excursions based on Algiers during the period of the Session; and a fourth series to French West Africa in October. Full details can be obtained from the Secrétaire-Général du Comité d'Organisation du 19e Congrès Géologique International, Faculté des Sciences, Alger, Algérie.

Faraday Society General Discussions in Cambridge and Toronto

The Faraday Society is holding two General Discussions, one on "The Physical Chemistry of Proteins", in the Department of Zoology, University of Cambridge, during August 6–8, and the other on "The Reactivity of Free Radicals", in the University of Toronto, Canada, during September 8–9. The Cambridge meeting will commence with the sixth Spiers Memorial Lecture, given by Dr. J. T. Edsall, of Harvard University. The programme will then be divided into the following five sessions: experimental techniques, proteins of low molecular weight, systems of high molecular weight, protein interactions, and conjugated proteins (nucleo- and muco-proteins). Twenty-four papers have been arranged for the meeting, advance proofs of which will be circulated by about July 16; these papers will be taken as read, and authors will be permitted to speak for five minutes only, before the subject is thrown open for discussion. Application to attend the meeting must be made before July 23. The Discussion in Toronto will open with a general introduction by Dr. E. W. R. Steacie, president of the National Research Council, Ottawa. Twenty-three papers will be presented, and the programme will be in two parts: reactions in the gas phase, and reactions in the liquid phase. Further information on the two Discussions can be obtained from the Secretary of the Faraday Society, 6 Gray's Inn Square, London, W.C.1.

Biology and Productivity of Hot and Cold Deserts

The Institute of Biology is organizing a symposium on "The Biology and Productivity of Hot and Cold Deserts", which will be held at the Royal Institution, Albemarle Street, London, W.1, during September 25–27. The symposium will be opened by Dr. Edward Hindle, and twenty-nine papers will be presented. There will be six sessions as follows: climate and physical environment; plant ecology; entomology and ecology; economic aspects; and mammalian physiology and ecology (two sessions). Further information can be obtained from the Secretary of the Institute, Tavistock House South, Tavistock Square, London, W.C.1.

Electronics Symposium and Exhibition in London

The Electrical and Electronics Section of the Scientific Instrument Manufacturers' Association is holding its fourth Symposium and Exhibition in the Examination Hall, Queen Square, London, W.C.1, during September 2–5. As in previous years, the Symposium will consist of a series of technical papers read by specialist scientific workers and engineers, with an open discussion on instrument users' problems. There will also be a comprehensive display of the latest types of British scientific and electronic instruments, most of which will be shown in operation during the period of the Exhibition. Entrance to the Exhibition is by presentation of a trade card. For the Symposium a ticket of admission is necessary (covering also the Exhibition), obtainable from the Secretary of the Scientific Instrument Manufacturers' Association, 20 Queen Anne Street, London, W.1.

Research on Safety in Mines

The Seventh International Conference of Directors of Safety in Mines Research is being held at Buxton during July 7–12 at the Safety in Mines Research Establishment of the Ministry of Fuel and Power. Thirty-eight papers have been submitted for discussion from Austria, Belgium, Canada, France, Germany, Great Britain, Holland, Poland and the United States. Other countries represented include India, Nigeria, Turkey and Southern Rhodesia. The agenda is restricted to the discussion of scientific and technical research on problems of safety; health problems, including pneumoconiosis of coal miners, administrative and legal problems will not be discussed. Copies of papers submitted to the Conference may be obtained after July 12 from the Safety in Mines Research Establishment, Portobello Street, Sheffield.

Royal Meteorological Society: Officers

The following have been elected officers of the Royal Meteorological Society for the year 1952–53: *President*, Sir Charles Normand; *Vice-Presidents*, Sir David Brunt, Wing-Commander R. M. Poulter, Sir Robert Watson-Watt and W. M. Witchell; *Vice-President for Canada*, A. Thomson; *Vice-President for Scotland*, E. G. Dymond; *Secretaries*, Prof. P. A. Sheppard and R. G. Veryard (49 Cromwell Road, London, S.W.7); *Treasurer*, Dr. J. S. Farquharson; and *Editor*, Prof. P. A. Sheppard.

Standardized Nomenclature for Inbred Strains of Mice

An international committee consisting of T. C. Carter, L. C. Dunn, D. S. Falconer, H. Grüneberg, W. E. Heston and G. D. Snell has been studying the question of a standardized system of nomenclature for inbred strains and sub-strains of mice. A set of rules for naming such strains has been prepared, and has now been published (*Cancer Research*, **12**, No. 8). A fairly complete list of existing inbred mouse strains

is included, with approved symbols and the laboratories in which they are maintained. Reprints can be obtained from the Director, Laboratory Animals Bureau, Medical Research Council Laboratories, Holly Hill, Hampstead, London, N.W.1; or from Dr. G. D. Snell, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

The Night Sky in July

FULL moon occurs on July 7d. 12h. 33m., U.T., and new moon on July 21d. 23h. 30m. The following conjunctions with the moon take place: July 2d. 16h., Mars 4° N.; July 16d. 04h., Jupiter 7° S.; July 24d. 04h., Mercury 2° S.; July 28d. 04h., Saturn 7° N.; July 30d. 19h., Mars 4° N. Mercury, an evening star, sets at 21h. 40m., 21h. 10m. and 20h. 0m. at the beginning, middle and end of the month, respectively, and is visible in the western sky after sunset, stellar magnitude 1·6. Venus sets too soon after the sun for favourable observation. Mars is an evening star, setting at 0h. 10m., 23h. 25m. and 22h. 35m. on July 1, 15 and 31, respectively, its stellar magnitude varying between −0·5 and 0. Towards the end of the month it is a little south of α Libræ. Jupiter is visible in the early morning hours, its times of rising being 0h. 50m., 23h. 55m. and 23h. 05m. at the beginning, middle and end of the month, respectively. Saturn is visible until late in the evening, its times of setting being 23h. 50m., 22h. 55m. and 21h. 55m. on July 1, 15 and 31, respectively. The planet is close to γ Virginis throughout the month and its stellar magnitude is 1·1. Occultations of stars brighter than magnitude 6 are as follows, observations being assumed at Greenwich: July 10d. 0h. 01·2m., 44 Capr. (*R*); and July 10d. 0h. 24·1m., 45 Capr. (*R*). *R* refers to reappearance. The earth reaches aphelion on July 3.

Announcements

DR. FRANS VERDOORN, editor of *Chronica Botanica* and chairman of the International Phytohistorical Commission, Waltham, Mass., has been elected a corresponding member of the Royal Netherlands Academy of Sciences of Amsterdam.

THE title of reader in chemical pathology (cancer research) in the University of Birmingham has been conferred on Dr. D. L. Woodhouse, lecturer and senior research fellow. The following appointments have recently been made in the University: W. O. Storer, to be lecturer in education (mathematics), in succession to E. C. Cull, who is retiring; R. F. King, to be Imperial Chemical Industries, Ltd., fellow in geology.

THE Chemical Society is offering a Corday–Morgan Award for 1951, consisting of a silver medal and monetary prize (150 guineas), which will be made to the British chemist who, in the judgment of the Council, published during the year 1951 the most meritorious contribution to experimental chemistry, and who, at the date of publication, had not attained the age of thirty-six years. Applications or recommendations in respect of the Award must be received not later than December 31, 1952. Further information can be obtained from the General Secretary of the Society at Burlington House, London, W.1.

AN Arnold Gerstenberg Studentship for 1953 (£170 a year for two years) is being offered to students in the University of Cambridge with honours in the Natural Sciences Tripos, who went into residence not earlier than the Easter Term of 1947, and who wish to pursue a course of philosophical study. The Studentship will be awarded for an essay which must be submitted before June 1, 1953. Full details can be obtained from Mr. R. B. Braithwaite, King's College, Cambridge.

THE eighth meeting of the International Commission on Glass will be held in London and Sheffield during June 30–July 5, under the presidency of Prof. W. E. S. Turner. The Commission, which includes the leading glass technologists from all Western European countries, Japan and the United States, exists to promote co-operative effort between members, to act as a clearing house for international, technical and scientific work and to transmit to the constituent societies scientific problems of international importance. Further particulars can be obtained from the Glass Manufacturers' Federation, 17 Manchester Street, London, W.1.

A MACHINERY and Implement Exhibition will be held at the Sports Turf Research Institute (formerly Board of Greenkeeping Research), St. Ives Research Station, Bingley, Yorkshire, during July 15–16. The laboratories at the Research Station, the experiment grounds and the Permanent Implement Exhibition will be open for inspection.

THE 'Present Question' Conference this year will be on "Conflicts of Loyalties" and will be held at Lady Margaret Hall, Oxford, during August 2–9. A number of lectures will be given in the mornings by leading experts, each one of whom will discuss a particular facet of conflicting loyalties in contemporary life. In the late afternoons and evenings study groups and discussions will be held. The fee for the Conference is 2 guineas (students, 1 guinea). Further details can be obtained from the Secretariat, Present Question Conference, 37 Middleway, London, N.W.11.

A WORLD Congress of Medical Practitioners for the Study of the Actual Conditions of Life will be held during October 16–18 in Montecatini, a well-known spa between Pistoia and Pisa. The Congress, which will be on the lines of the International Medical Congress held in Rome during November 10–11, 1951, will be under the presidency of Prof. Pietro Verga, director of the Institute of Anatomy and Pathological Histology and of the Institute for Cancer Research, University of Naples. Three themes will be discussed: conditions of life and the health of populations; the repercussions of the Second World War on physical and mental health; and the duty of medical practitioners with regard to these problems. Further information can be obtained from the Secretariat of the Congress, Corso Trieste 65, Rome.

THE Departments of Extra-Mural Studies and of Electrical Engineering of the University of Birmingham are arranging a summer school on the fundamental characteristics of electronic apparatus, to be held in the University, Edgbaston, during July 14–19. The course is intended for engineers and others of university degree or similar standing in electrical technology who have some general knowledge of electronics. The following topics will be discussed: limitations of thermionic valves, thyratrons and ignitrons, circuits, semi-conductors, photo-cells and magnetic amplifiers; each topic will be introduced by a theoretical lecture, and will be followed by consideration of particular applications. The fee for the course is £2. Further details can be obtained from the Director of Extra-Mural Studies, University, Edmund Street, Birmingham 3.

DETERMINATION OF CRYSTAL STRUCTURE BY OPTICAL DIFFRACTION METHODS

In some recent publications[1–5], we have advocated the use of optical diffraction methods in crystal-structure determination, and have shown how they could have been applied to some known structures. The test of the methods, however, lies in their application to new problems, and this present communication is intended to give a review of what has been achieved so far.

Five structures have been successfully determined. For the simplest ones, optical methods, supplemented by knowledge of the stereochemistry of the molecule, proved to be entirely adequate; but for the others we have made use of such other information as would normally be available at the outset of an investigation. The characteristic of the methods is that no calculation is needed until the 'refinement' stage is reached.

The five structures are as follows:

(*a*) *p*-Di-*iso*cyanobenzene[6] (Fig. *a*). Space group $C2/m$; $a = 9{\cdot}80, b = 7{\cdot}15$, $c = 4{\cdot}72$ A., $\beta = 97°\ 11'$. Molecules on $2/m$.

(*b*) Diphenylene naphthacene (Fig. *b*). Space group $P2_1/c$; $a = 11{\cdot}0$, $b = 5{\cdot}15$, $c = 19{\cdot}6$ A., $\beta = 126°$. Molecules on $\bar{1}$.

(*c*) Thiourea dioxide (Fig. *c*). Space group $P2_1nb$; $a = 9{\cdot}95$, $b = 10{\cdot}64$, $c = 3{\cdot}93$ A. Molecules in general positions.

(*d*) Di-*p*-anisyl nitric oxide (Fig. *d*). Space group $Aba2$; $a = 7{\cdot}33$, $b = 26{\cdot}8$, $c = 6{\cdot}08$ A. Molecules on 2.

(*e*) Purpurogallin. Space group (effectively) $P2_12_12$; $a = 9{\cdot}78$, $b = 24{\cdot}6$, $c = 3{\cdot}65$ A. Molecules in general positions.

The problems are arranged roughly in order of complexity. The first one—*p*-di-*iso*cyanobenzene—could have been readily solved by any method, but the solution by the Fourier-transform method was almost immediate. The factor of agreement with the atomic parameters derived[6] was 0·185.

The second—diphenylene naphthacene—was of the same order of complexity as phthalocyanine[1], and exactly similar methods were used. In addition, of the sixty-three signs determined by the methods described by Lipson and Taylor[3], only two were found to be incorrect. The factor of agreement given by the first parameters was 0·28.

The third structure—thiourea dioxide—was more difficult at the outset because, although the chemical molecule contains only six atoms (neglecting hydrogen), the chemical constitution was uncertain. Initially it was thought that the space group was *Pmnb*, and thus that the molecules lay on mirror planes; on this basis the signs of the structure factors were found by the Fourier-transform method[3], the most likely form of molecule being assumed. Optical Fourier synthesis[2,5], however, showed only the positions of the sulphur atoms, but by systematic exploration of sign combinations of some of the less certain terms, a recognizable representation of the complete molecule was obtained optically. It is now known that this structure is only approximate, the space group probably being $P2_1nb$.

In the fourth structure—a free radical, di-*p*-anisyl nitric oxide—the stereochemistry was only approximately known. By trial of various possibilities, suggested by the Fourier-transform method and by packing considerations, a projection was found that gave reasonable agreement, and calculation showed that the factor of agreement was about 0·35.

The fifth structure—purpurogallin—is of a different standard of complexity from the others, and, since the methods used show clearly the value of the optical approach, it is dealt with in a separate communication[7].

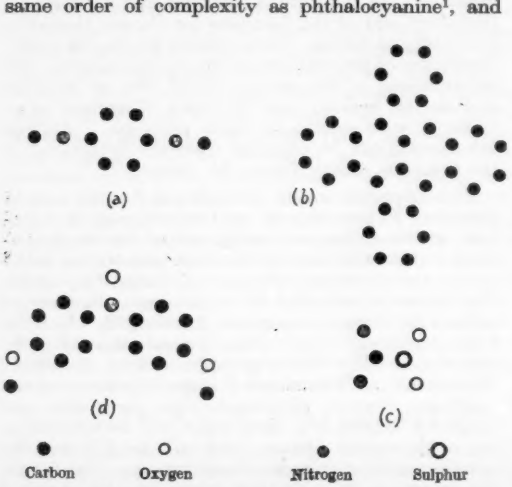
From these results, it would appear that the Fourier-transform method[3] is the most powerful of the methods we have advocated, and is greatly helped by the modified 'fly's eye' device[4]. Optical Fourier synthesis[2,5] is likely to be of much more limited application, unless it is possible greatly to extend the area (about 4½ in. in diameter) of the beam of parallel light available in the present apparatus.

We are grateful to Dr. I. G. Edmunds and Mr. A. Bennett, and to Mr. B. M. Hargreaves, of Messrs. Hardman and Holden, Ltd., for allowing us access to their data on diphenylene-naphthacene and thiourea dioxide respectively, and to Dr. A. Burawoy for providing us with a specimen of di-*p*-anisyl nitric oxide. We also wish to record our thanks to the Department of Scientific and Industrial Research and to the Council of the Royal Society for grants towards the building of the apparatus.

The methods and results will be described in greater detail elsewhere.

A. W. Hanson
C. A. Taylor
H. Lipson

Physics Department,
College of Technology,
Manchester 1. April 23.



Representations of chemical molecules. (*a*) *p*-Di-*iso*cyanobenzene. (*b*) Diphenylene naphthacene. (*c*) Thiourea dioxide. (*d*) Di-*p*-anisyl nitric oxide

[1] Taylor, C. A., and Lipson, H., *Nature*, **167**, 809 (1951).
[2] Hanson, A. W., Taylor, C. A., and Lipson, H., *Nature*, **168**, 160 (1951).
[3] Lipson, H., and Taylor, C. A., *Acta Cryst.*, **4**, 458 (1951).
[4] Hanson, A. W., and Lipson, H., *Acta Cryst.*, **5**, 145 (1952).
[5] Hanson, A. W., and Lipson, H., *Acta Cryst.* (in the press).
[6] Hulme, R., *Acta Cryst.*, **5**, 144 (1952).
[7] Taylor, C. A. (see following communication).

Purpurogallin: by Optical Diffraction Methods

THE unit-cell dimensions found for purpurogallin, $C_{11}H_8O_5$, indicate that the molecules, which are assumed to be planar, lie almost parallel to the (001) planes and that they do not overlap in the *c*-axis projection. The present communication is concerned only with this projection, and the structure is described in terms of the plane-group *pgg*, with four molecules in general positions in a cell which has $a = 9{\cdot}78$ and $b = 24{\cdot}6$ A. There are certain complications in the full three-dimensional structure which need not concern us here.

The weighted reciprocal-lattice section containing the *hk*0 reflexions is given in Fig. 1 and the form assumed for the molecule is indicated in Fig. 2. It will be observed that the molecule contains one six-membered ring and that a number of the atoms adjacent to this ring form portions of regular hexagons approximately parallel to it. The transform of any regular hexagonal arrangement of atoms contains six peaks which, if the molecule lies in the plane of projection, lie at equal intervals around a circle with its centre at the origin and of radius $0{\cdot}83$ A.$^{-1}$. (We have called this the 'benzene circle' since the peaks appear in the transform of any molecule containing a benzene ring.) If the molecule is tilted out of the plane, some or all of the peaks will move away from the circle. In purpurogallin there are four molecules of different orientation; but since they are related by two-fold axes (equivalent to centres of symmetry in projection) there are only two different orientations of the hexagon to consider, and we should therefore expect to find twelve peaks in the transform of a complete unit cell. Since the molecules lie close to the plane of projection, these peaks should appear close to the benzene circle. An inspection of Fig. 1 (on which the benzene circle has been indicated) shows at once that there are twelve strong reflexions in about the expected positions. Closer inspection shows that there are, in fact, twelve *groups* of reflexions (indicated by broken lines on one half of the diagram), which give a clear indication of the positions of the peaks in the underlying transform. The orientation of the hexagonal portions of the molecules with respect to the three crystallographic axes follows immediately.

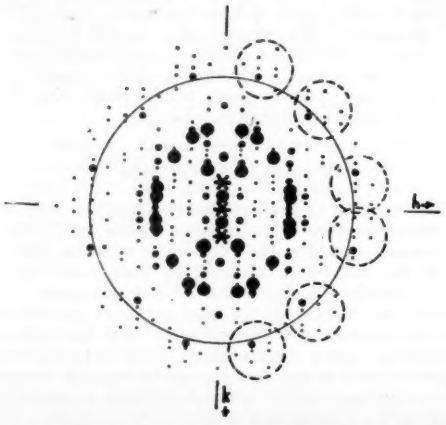


Fig. 1. Weighted reciprocal-lattice section containing the *hk*0 reflexions for purpurogallin. The 'benzene circle' is also shown

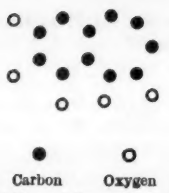


Fig. 2. Assumed form of the molecule of purpurogallin

On the basis of this deduction, together with some simple packing considerations, and the fact that the 040 reflexion is particularly strong, a set of atomic positions was postulated. These were then checked and modified slightly by the optical method[1,2]. When reasonable agreement seemed to have been obtained, the signs of the structure factors were determined optically[2] and a calculated Fourier synthesis with these signs showed all the atoms unequivocally.

Two points are emphasized by this result:

(1) A considerable amount of information can be derived directly from the weighted reciprocal-lattice section without explicit use of optical transforms.

(2) Subsequent calculation showed that the factor of agreement of the first proposed structure was about 0·6, but a large proportion of the signs derived optically proved to be right. The factor of agreement fell to less than half this figure for the atomic positions derived from the first Fourier synthesis. This underlines the fact that although optical methods may not always lead directly to a structure with a small factor of agreement, they do lead to structures which can be rapidly refined, that is, which have a high proportion of correct signs. This arises naturally from the method employed. Fourier transforms of centrosymmetrical projections consist of peaks within which the phase is constant, separated by zero lines across which the phase changes[3]. Optical methods aim at placing the majority of the reciprocal-lattice points on the correct peaks of the transform; subsequent refinement corresponds to finding the correct position within a given peak. Obviously there is much more latitude in finding the right peak than in finding the correct position for each reflexion, which is effectively the aim of methods based on quantitative agreement.

I am indebted to Mrs. D. Hodgkin for suggesting the problem and allowing me to make use of the X-ray data. These data had been available for some time; but work had not been carried beyond the earliest stages because of the large amount of computational work involved. The optical methods proved to be quite rapid, the work described, although interspersed with teaching and other duties, being completed in about five weeks.

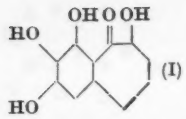
C. A. TAYLOR

Physics Department, College of Technology, Manchester 1. April 23.

[1] Taylor, C. A., and Lipson, H., *Nature*, **167**, 809 (1951).
[2] Lipson, H., and Taylor, C. A., *Acta Cryst.*, **4**, 458 (1951).
[3] Taylor, C. A., *Acta Cryst.*, **5**, 141 (1952).

Purpurogallin: by X-Ray Fourier Synthesis

ALTHOUGH the oxidation product of pyrogallol, purpurogallin, has been known to chemists for more than eighty years, its structure remained unsolved until Barltrop and Nicholson[1], and almost simultaneously Haworth, Moore and Pauson[2], formulated it as the benzo-tropolone derivative (I). This

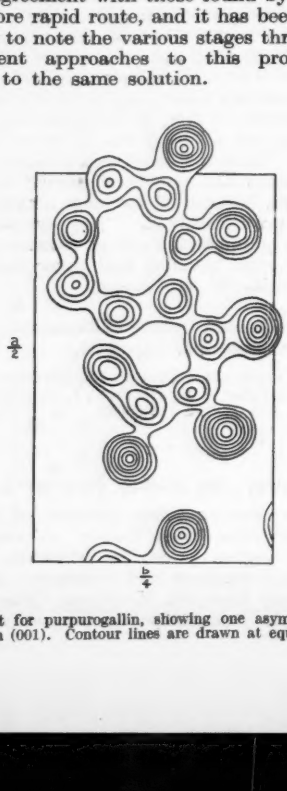


(I)

structure has now been completely confirmed by X-ray analysis, by the results of Taylor[3], and by the present investigation.

Crystals of purpurogallin, $C_{11}H_8O_4$, may be referred to orthorhombic axes, $a = 19{\cdot}56$, $b = 24{\cdot}6$, $c = 3{\cdot}62$ A., $Z = 8$, space-group $Pb2a$. For odd values of h, additional, weak, diffuse reflexions which lead to doubling of b and breakdown of orthorhombic symmetry are observed. These indicate the existence of some kind of disorder, the nature of which is not yet completely understood. Thus far, the analysis has been confined to a study of the (001) projection, which appears to be free from disorder. A centrosymmetric distribution of scattering matter is indicated by analysis of the intensity distribution of the $hk0$ reflexions[4,5], and since $h00$ reflexions appear only for $h = 4n$, the plane-group of the projection can be regarded as pgg.

The structure analysis in Oxford was eventually carried out mainly by trial and error methods, the various possibilities being limited by the requirements that the molecular plane should correspond approximately with the projection plane (because of the shortness of the c-axis), and that four hydrogen bonds per molecule be formed. These restrictions enabled the molecular orientation and the translation parameter along b to be fixed with reasonable certainty; the remaining translation parameter (along a) presented more severe difficulties and was ultimately determined only after rather laborious trial. The latest Fourier plot is reproduced herewith, from which the general features of the molecule are clearly seen. The atomic positions finally reached are in excellent agreement with those found by Taylor, by a much more rapid route, and it has been especially interesting to note the various stages through which our different approaches to this problem have converged to the same solution.



Fourier plot for purpurogallin, showing one asymmetric unit projected on (001). Contour lines are drawn at equal intervals

Much of the preliminary X-ray work on purpurogallin was carried out by Drs. A. Addiamano and C. Brink. I am also indebted to Dr. J. A. Barltrop for having provided us with crystals, and to Mrs. D. Hodgkin for having brought this problem to my notice.

J. D. Dunitz

Laboratory of Chemical Crystallography,
University Museum,
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May 27.

[1] Barltrop, J. A., and Nicholson, J. S., *J. Chem. Soc.*, 116 (1948).
[2] Haworth, R. D., Moore, B. P., and Pauson, P. L., *J. Chem. Soc.*, 1045 (1948).
[3] Taylor, C. A. (see preceding communication).
[4] Wilson, A. J. C., *Acta Cryst.*, **2**, 318 (1949).
[5] Howells, E. R., Phillips, D. C., and Rogers, D., *Acta Cryst.*, **3**, 210 (1950).

PROPERTIES OF THE CYTOCHROME SYSTEM OF LIVING WHEAT ROOTS

By Prof. H. LUNDEGÅRDH
Institute of Plant Physiology, Uppsala, 7

BY means of a specially constructed automatic spectrophotometer, the properties of the cytochrome system of wheat roots were studied under normal conditions of growth and under the influence of various inhibitors affecting single cytochromes, or enzyme systems linked to them[1].

The cytochrome system of wheat (and maize) roots is composed of three distinct enzymes: cytochrome oxidase (or cytochrome *a*), cytochrome *c* and cytochrome *b* (Fig. 1). A second cytochrome *a* in addition to the oxidase[2] could not be identified. The living roots hold a few other coloured substances tentatively identified as a flavoprotein (450 mμ), a band at 575 mμ belonging to a substance with an oxidation-reduction potential between cytochrome *b* and the succinic dehydrogenase and possibly representing a factor between these enzymes, peroxidase (bands at 402·5 and 615 with fluoride; cf. ref. 3), and an unidentified strong band at 482·5 mμ. By the use of suitable inhibitors and conditions of oxidation or reduction it was possible, however, to avoid optical complications which might be introduced by the last-named substances.

Cytochrome Oxidase

This enzyme is very probably identical with that in heart muscle. The turnover number (T.N.) of the wheat cytochrome oxidase is 1,700 at 19°, or about the same as calculated by Ball *et al.*[4] for the heart muscle if a Q_{10} value of 2 is assumed. The γ-band at *c.* 415 mμ of the oxidized cytochrome oxidase appears in roots fed with salts and showing maximum 'anion respiration'[1]. The reduced bands appear at 442·5 and 602 mμ. The relation between the extinctions of the γ- and α-bands is about the same as for cytochrome *c*.

The response of the cytochrome oxidase to cyanide and carbon monoxide deviates partly from what is

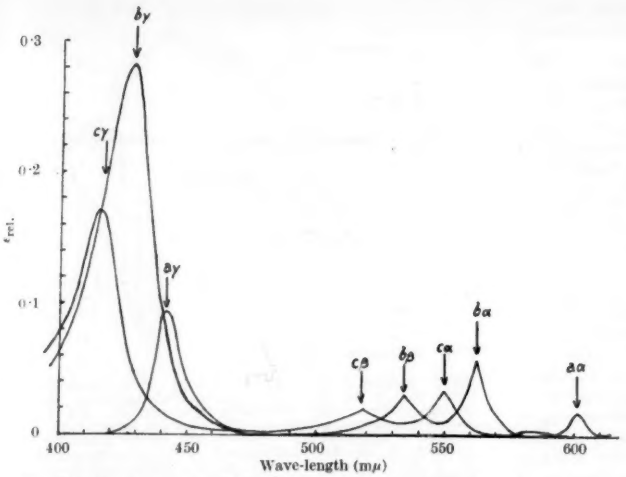

Fig. 1. Reduced absorption spectra of cytochrome oxidase (*a*) and cytochromes *c* and *b* composing the cytochrome system of wheat roots. The heights of the bands correspond to the relative quantities of the components

known from biochemical preparations. The cytochrome oxidase of the living roots is completely reduced in the absence of oxygen, but also in the presence of cyanide or carbon monoxide. The reduced bands are partly shifted under the influence of these inhibitors, as earlier described in the literature; but the γ-band at 442·5 is still maintained at nearly full intensity together with the new cyanide or carbon monoxide band at 430–435 mμ. The initial effect of the inhibitors is probably competitive against oxygen (cf. ref. 5), thus expelling the oxygen from the active surface of the oxidase and causing an 'aerobic anaerobiosis'. With prolonged treatment and higher concentrations, chemical compounds between inhibitor and oxidase predominate, however.

The cyanide inhibition exhibits an extremely rapid time course. The inhibition begins at 10^{-7} *M* hydrogen cyanide and the half-period only amounts to 20–30 sec., or *c.* 1/20 of the rate attained by any other substance entering the roots except low-molecular alcohols. The rapid response to cyanide suggests a localization of the cytochrome oxidase near the surface of the cells. Experiments on the oxidation of added reduced cytochrome *c* by living roots strongly support this conclusion. Living roots oxidize added cytochrome *c* at a rate corresponding to *c.* 1/125 of the total activity of the cytochrome system of the roots. Calculation from anatomical factors yields about the same value for the quotient (surface of the roots)/(surface of all cortex cells). The conclusion may be justified that the cytochrome system of wheat roots is localized in or near the surface of the living protoplasm, perhaps as a macromolecular component of the protoplasmic membrane itself.

Cytochrome *b*

For optical isolation of the single cytochromes, the spectrum of reduced cytochrome *c*, calculated from the extinction at 415 mμ, was subtracted from the crude absorption spectrum of the roots or from the oxidation-reduction spectrum ($\varepsilon_{red} - \varepsilon_{ox}$); furthermore, the spectrum of the cytochrome oxidase was calculated from the extinction of the band 602 mμ. What remains of the crude spectrum after these subtractions corresponds to cytochrome *b*. The results were corroborated in different ways, as the oxidation-reduction balance of the single cytochromes can be individually changed under the influence of certain inhibitors. A pure spectrum of cytochrome *b*, for example, is obtained after treatment with 10 per cent urethane. After oxidation, cytochrome *b* remains reduced. Optical isolation of the cytochrome oxidase is achieved after treatment with hydrogen cyanide and subsequent change to fumarate + hydrogen cyanide. Cytochromes *c* and *b* are thereby oxidized, whereas the oxidase remains reduced, etc.

The cytochrome *b* of the roots has its γ-band at *c.* 418–420 mμ oxidized and *c.* 427 mμ reduced. The β- and α-bands appear at 535 and 562 mμ. The relative heights of the bands are very similar to the values obtained for cytochrome *c*. In spite of the somewhat smaller value in mμ of the γ-band (cf. ref. 2), identity with the cytochrome *b* from animal tissue is very probable. The bands are not moved under the influence of cyanide or carbon monoxide, but the β- and α-bands are slightly weakened. At complete anaerobiosis (oxygen-free water solution), the α-band is partly masked by the previously mentioned band at 575 mμ. This band, however, is moved to 580–585 mμ under the influence of cyanide or carbon monoxide, leaving the bands of cytochrome *b* free.

Oxidation-reduction Balance of the Cytochrome System

The relative molar quantities of the three cytochromes are illustrated by Fig. 1. Assuming identical molar (Fe) extinction values, the relations are about 1 *a* : 2 *c* : 3–4 *b*. The absolute quantity of cytochrome *c* is about 20 mgm. per kgm. fresh weight, or 250 mgm. per kgm. dry weight; thus the concentrations are comparable with those known from animal tissues[7]. A difference is the preponderance of cytochrome *b* instead of *c*; but there are cases of very low values of *c* also in animal tissue[8].

The observation of the variation of the oxidation-reduction balance of the single cytochromes enables certain approximate calculations of the potentials. The oxidation-reduction potential of cytochrome *b* is lower than that of cytochrome *c* ($E_0 = 0{\cdot}254$ at biological *p*H-values), probably 0·14–0·17. A strongly oxidized cytochrome *b* can partly oxidize cytochrome *c*. The possibility cannot be excluded that cytochrome *b* is directly oxidized by the oxidase too. The comparatively high potential of *b* indicates the presence of still another factor between *b* and the dehydrogenases, perhaps identical with the band at 575 mμ already mentioned.

The potential of the cytochrome oxidase is considerably higher than that of cytochrome *c*, tentatively between 0·37 and 0·50. The large gap completely prevents a reoxidation of the oxidase during anaerobical oxidation of cytochrome *c* with fumarate.

Linkage of the Cytochrome System to the Dehydrogenases

Cytochrome *b* is linked to the succinic dehydrogenase, probably by means of an intermediate factor (cf. ref. 9 and above). Succinic dehydrogenase is inhibited by 0·1 *M* malonate at low *p*H-values (2·8–3·2; cf. ref. 6). Cytochrome *b* is then oxidized to *c*. 75–90 per cent (in aerated distilled water it is *c*. 50 per cent oxidized). A nearly complete oxidation (100 per cent) is attained in fluoride (0·02 *M*, *p*H 3·2; cf. ref. 6). The malonate inhibition is reversed by fumarate. Fumarate oxidizes both cytochromes *b* (predominantly) and *c*, thus proving the existence of reversible equilibria not only between *b* and succinic dehydrogenase but also between cytochromes *b* and *c*.

The oxidation of cytochrome *b* in fluoride is certainly not caused by a competitive inhibition of succinic dehydrogenase, as in the case of malonate and pyrophosphate, but by a decreasing supply of succinate. That fluoride checks the production of C_4-acids is probably one of the reasons why growth and bleeding are so strongly affected by sodium fluoride (see refs. 6, 10). The inhibited production of acids saves the protoplasm from destruction, and cells treated with sodium fluoride maintain their normal appearance, protoplasmic streaming and surface potential. Malonate does not stop the production of acids, only their combustion. Malonate inhibition causes accordingly strong vacuolization of the protoplasm and is far more poisonous than fluoride (cf. ref. 6).

On inhibition of succinic dehydrogenase by malonate or fluoride, the cytochrome oxidase remains active and maintains a considerable respiration above the level of the ground respiration (= a fraction of the total respiration resistant to cyanide). The first-named respiration is easily inhibited by cyanide or carbon monoxide and includes cytochromes *c* and *a* and a second dehydrogenase system, possibly identical with a cozymase–flavoprotein system observed in tissue homogenates[9]. A similar system is claimed to operate in wheat roots in connexion with ascorbic acid oxidase (Cu-protein = oxidase II; cf. ref. 10). It may be tentatively assumed that a flavoprotein system supplying the 'ground' respiration of the roots[5,6,11] may also be linked to cytochrome *c* as an alternative pathway of end-oxidation with inhibited succinic dehydrogenase (see Fig. 2).

Interaction of Cytochromes and Anions

According to the theory of anion (or salt) respiration[5,6,11,14], the active transport and accumulation of electrolytes—primarily neutral salts and organic acids—is linked to the transference of electrons and protons from the dehydrogenases through the cytochrome system to oxygen.

Only the complete cytochrome system is able to accumulate anions. If succinic dehydrogenase and cytochrome *b* are out of action, for example, under the influence of fluoride, the cytochrome respiration may continue but the power of salt accumulation is lost. It may be tentatively assumed that cytochrome *b* controls a structural barrier preventing the passive return-flow of accumulated salts (cf. ref. 1). This cytochrome *b* barrier is also affected by 2,4-dinitrophenol, known as an inhibitor of phosphorylation, indicating that the high-energy phosphate metabolism is in some way responsible for the maintenance of the structural basis of the system (cf. ref. 12).

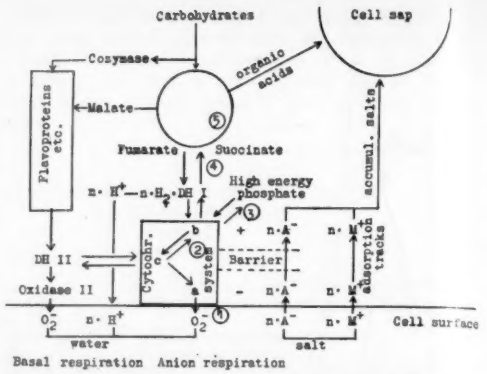

Fig. 2. Scheme of the cytochrome system and its linkage to the metabolism of the cell. A^- = anions (freely movable). M^+ = metallic cations. *DH* I = succinic dehydrogenase. *DH* II = a second dehydrogenase system. The encircled figures refer to a number of inhibitors: (1) cyanide and carbon monoxide are inhibiting the electron transference from the cytochrome oxidase to oxygen; absence of freely movable anions outside of the cytochrome system also induces an aerobic anaerobiosis. (2) Urethane inhibits the oxidation of cytochrome *b* by *c* and/or *a*. (3) 2,4-Dinitrophenol inhibits phosphorylation and disturbs the barrier function attached to cytochrome *b*, thus impeding salt accumulation. (4) Malonate and pyrophosphate inhibit the succinic dehydrogenase (*DH* I). (5) Fluoride inhibits the production of organic acids and brings the *DH* I system to a standstill. The intricate question as to the possible transference of electrons and protons from other dehydrogenase systems operating in the tricarboxylic cycle must be left open at present. Malate is chosen as one of the diverse points, from which a side transference may occur to a cozymase – flavoprotein – oxidase II system. The ~ *p*H metabolism has many ramifications and may only indirectly control the activity of cytochrome *b* and/or *c*

It is known that the cell surface is coated with a layer of anions and cations adsorbed from the medium[10,13]. The cytochrome system may co-operate directly with this adsorption layer, and the purpose of the anion respiration is to move the anions from this layer to a safe distance inside the protoplasmic membrane. The course of events may be summarized in the following equations.

(1) Oxidase $(Fe^{++}) + O_2 + anion$ = oxidase $(Fe^{++})^+ \cdot anion + O_2^-$

(2) Oxidase $(Fe^{++})^+ \cdot anion$ + cytochrome *c* (Fe^{++}) = oxidase (Fe^{++}) + cytochrome *c* $(Fe^{++})^+ \cdot anion$

(3) Cytochrome *c* $(Fe^{++})^+ \cdot anion$ + cytochrome *b* (Fe^{++}) = cytochrome *c* (Fe^{++}) + cytochrome *b* $(Fe^{++})^+ \cdot anion$

(4) Cytochrome *b* $(Fe^{++})^+ \cdot anion + DH\ I \cdot H_2$ = cytochrome *b* (Fe^{++}) + succinic dehydrogenase $\cdot H + H^+ + anion$.

(5) $O_2^{4-} + 4\ H^+ = 2\ H_2O$.

The anions liberated in reaction (4) are combined with cations from the internal adsorption points of the living structure[11,13], thus forming accumulated salts. The protons produced in reaction (4) are consumed in reaction (5). If the transport of anions is regarded as an electrophoresis (see ref. 1), the stream of protons from (4) to (5) represents the opposite movement of cations.

The anion respiration mechanism may, of course, also be able to transport anions of organic acids, for example, malate, auxin anions, etc.[6]. In complete absence of movable anions, reaction (1) is inhibited and the cytochromes *a* and *b* are then strongly reduced. The decrease of the reduction of the cytochromes if salts are again supplied is shown in Fig. 3. A limited 'idling' is maintained by hydroxyl ions from water; more prominent, however, is probably the 'idling' caused by the production of organic acids in the system itself[6]. For this reason only 50–75 per cent reduction is normally attained in the absence of salts.

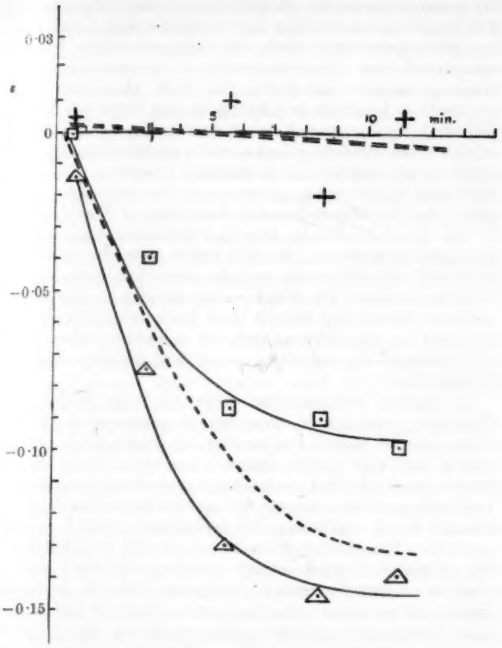

Fig. 3. Diagram of a combined experiment, illustrating the interaction of the cytochrome system and the active absorption of salt anions. The abscissa represents the height of the partly reduced bands in roots pretreated with distilled water for 48 hr. ⊡ cytochrome oxidase 443 mμ, △ cytochrome *b* 430 mμ, + cytochrome *c* 415 mμ. The height was automatically recorded in intervals of 2·5 min. At 0 min. the medium was changed from distilled water to 0·05 *M* potassium chloride. The subsequent oxidation of the cytochromes is reflected in the decreasing height of the bands of *a* and *c*, whereas *c* behaves more indifferently, probably owing to its linkage to side-reactions (cf. ref. 1). The absorption of chloride was recorded and its time-course (- - - - -) closely follows the decreasing reduction of the cytochromes *a* and *b*

The experimental results show that a fragmentary cytochrome system, including only *a* and *c*, can operate without salt accumulation. The anions required for compensation of the valency changes are here probably only circulating. It is even possible that cytochrome *c* is movable between the oxidase and the postulated second dehydrogenase system (cf. ref. 14). The more independent oxidation-reduction situation of cytochrome *c*, as compared with *a* and *b* (see Fig. 3; also ref. 1), supports the idea of its ambulatory character and its participation in enzyme systems outside the structurally anchored cytochromes. The barrier function of cytochrome *b* postulates a fixed linkage to a membrane structure.

A cytochrome system which is not anchored to a diffusion barrier will, of course, not accumulate salts; it will only contribute to a common stirring of the solutes around the structures. This may possibly be the case with systems located in mitochondria, etc. (cf. ref. 7). On the other hand, any oxidation-reduction system operating by means of electron transferences may be capable of transporting electrolytes, or absorbing and excreting ions, if it is combined with a barrier mechanism. So far no such system in addition to the cytochrome system has been closely studied. In respect of plants, our present knowledge points to the cytochrome system as the main salt-transporting mechanism.

A detailed report of the investigations will be published in *Ark. f. Kemi* (Swed. Acad. Sci., Stockholm).

[1] Lundegårdh, H., *Ark. f. Kemi* (Stockholm), **3**, 69, 469 (1951).
[2] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **127**, 167 (1939).
[3] Keilin, D., and Hartree, E. F., *Biochem. J.*, **49**, 205 (1951).
[4] Ball, E. J., *et al.*, *J. Biol. Chem.*, **193**, 635 (1951).
[5] Lundegårdh, H., *Ark. f. Bot.* (Stockholm), **32**, A, No. 12 (1945) (p. 39, Fig. 5); *Nature*, **165**, 513 (1950).
[6] Lundegårdh, H., *Ann. Agric. Coll. Sweden*, **16**, 339, 372 (1949).
[7] Paul, K. G., "The Enzymes" (Sumner and Myrbäck), **2**, pt. 1, 357 (1951).
[8] Tsou, C. L., *Biochem. J.*, **49**, 512 (1951).
[9] Slater, E. C., *Biochem. J.*, **45**, 14 (1949); **46**, 484 (1950).
[10] Waygood, E. R., *Canad. J. Res.*, C, **28**, 7 (1950).
[11] Lundegårdh, H., *Physiologia Plant.*, **3**, 103 (1950).
[12] Stenlid, G., *Physiologia Plant.*, **2**, 350 (1949).
[13] Lundegårdh, H., *Ann. Agric. Coll. Sweden*, **8**, 233 (1940).
[14] Robertson, R. N., "Ann. Review Plant Physiol.", **2**, 1 (1951).

FUTURE OF HIGHER TECHNOLOGICAL EDUCATION IN BRITAIN

THE second of a series of meetings organized by the Staff Association of the Royal Technical College, Glasgow, to discuss the future of higher technological education was held in the College on May 27 and addressed by Prof. J. F. Baker, head of the Department of Engineering, University of Cambridge.

Prof. Baker, who was speaking on higher technological education from the point of view of the universities, began with a short historical review. Throughout the nineteenth century, a handful of professors of engineering struggled to convince employers that the subject was a science requiring specialized teaching, and was not merely a craft which could be taught best during an apprenticeship. Although hampered by lack of funds, engineering laboratories began to be established about 1870, and did much to bridge the gap between theory and practice. The value of the application of science to industrial problems was more fully realized during the First World War, although even in the 'thirties some firms employing graduate engineers had little idea how to make the best use of them. The universities themselves were not free from blame in this matter, the courses being often too narrow and specialized.

Contending that education for the various branches of technology is an essential function of the universities, Prof. Baker instanced the medical faculties. Medicine, an old and well-organized profession, long ago established its rights in the universities, although it is essentially a technology.

Prof. Baker continued by pointing out the difficulties of teaching a subject the application of which is essentially practical: "while the fundamentals must be sound, practice can never be ignored". With such a vast and ever-expanding field as that covered by engineering, it must be decided what parts must be played by the university and what by industry in the education and training of the student. He was convinced that the intellectual discipline involved in technological education is second to none.

Dealing with the teaching of technology, Prof. Baker said that ideally the product of such education should be a man who by the age of thirty is master

of the theory and practice of his particular branch, with a wide knowledge of science equipping him to break new ground, and also a man of culture and character able to deal with men and administrative problems. This is obviously an impossible specification for all but the rare genius. To produce the results required to-day, industry must employ a partnership of different types. Two approaches to teaching are possible: first, to work from the particular to the general, illuminating practice by theory and maintaining a strong practical engineering emphasis; second, to concentrate on theory, with the main approach from mathematics and physics, leaving the junction of theory and practice to be worked out in industry. Each university must recognize the limitations of these two approaches and choose its own course accordingly.

In spite of the demand from some quarters for more advanced technical courses, Prof. Baker was emphatic that the universities would be wise to concentrate on the fundamentals. He is opposed to any extension of the length of undergraduate courses and believes that the proper time for specialized technological studies is in a postgraduate course.

In the important matter of training engineers in the universities, the teaching staff must, above all, be engineers, who would be concerned with the application of scientific principles, instil the idea of precision and help to develop a creative attitude. The staff must keep in touch with practice either by engaging in applied research or in a high standard of consulting work.

Prof. Baker then strongly recommended the foundation of postgraduate courses to meet the needs of those graduates who, after about five years experience in industry, are eager to pursue the study of their particular line of work to a higher level. Their maturity in the practice of their profession would enable them to appreciate to the full advanced knowledge. In addition, the presence of these men in the university would be of great value in stimulating the teaching staff to new vigour and enthusiasm, which would in turn influence the undergraduate courses.

A wide general scientific education should be the aim for the undergraduates, while the postgraduate courses would complete the training of the best technologists, so providing for the needs of an expanding industry and stimulating progress.

A contribution from Dr. James Taylor, managing director of the Nobel Division of Imperial Chemical Industries, Ltd., was read in his absence by Dr. David Traill, research manager of the Division. In his opening remarks, Dr. Taylor, who dealt with the relation of higher technological education to industry, defined the technologist as "one who engages in the scientific study of the practical or industrial arts, and in the practical application of scientific principles and discussions to the arts and industry", and emphasized the collective importance of the technician, the technologist and the pure scientist in the growth of any healthy and progressive industry. He next examined the American thesis that, while Britain is abreast and in some cases ahead of the Americans in many branches of research, technical stagnation has ensued due to a failure of technical re-equipment and tardiness in technical innovation. In assessing how far the present training of chemists contributes to this reluctance in technical innovation, he said that the intellectual atmosphere of the training which regards research as an end in itself has two effects: "it tends to make the chemist non-critical of problems which are given to him for experimental study and too little concerned with the outcome when he has completed his investigation". Considering the training aspect generally, he felt that the first requisite is a sound grounding in the basic principles followed by a period of research in a university school if the student plans to take up the fundamental exploratory aspect of industrial research, or by a chemical engineering course (as, for example, that given by the Massachusetts Institute of Technology) if his interests lie in the development and plant-operational aspects. In the latter case the essential 'clinical' experience can only be provided by industry.

In conclusion, Dr. Taylor supported a recent statement by Sir Arthur Smout that more attention should be paid to the liberal side of scientific education, "to promote the inquiring mind and develop original thought".

A written contribution received from Mr. A. S. Danchev, lecturer in mechanical engineering in the New South Wales University of Technology, Australia, referred to the direct connexion which exists between an efficient technology and the right kind of technological education. He submitted that there is a need for a university of technology which would provide a broad educational background coupled with an enlightened professional training. In its courses, such a university would recognize that its primary aim is to produce "thinking men, men of judgment and initiative" capable of formulating and implementing an industrial policy. To that end it would institute a blend of theoretical and practical courses so that the practical operations within a technology would always be presented in relation one to the other and to the integrated whole. In conclusion, Mr. Danchev pointed out that universities of the type referred to are favoured in Europe, in the United States, and have recently been introduced in Australia.

In the varied discussion which followed, many contributions were based on personal experiences in the United States and Europe.

Criticism of the present British university system was mainly founded on the agreed view that sufficient technologists suitably trained to be effective in industry are not being produced. This led several speakers to advocate the establishment of universities of technology.

One cited the close co-operation existing in Switzerland between the research laboratories of firms and local colleges. This followed from frequent interchanges of staffs between them, many of the professors in the colleges having held high positions in the industries. Such exchanges led to a rapid diffusion of new knowledge into industry and also allowed local industries to have a strong influence on the development of theoretical work in the colleges. Now that technology has become internationally competitive, such co-operation is becoming a necessity for Britain. But such 'double harness' conflicts with the traditional freedom of British universities to develop in their own way and time.

Referring to Prof. Baker's view that, until a man has been into industry, research should not form part of his training as an engineer, another speaker maintained that, without the attraction of research and the opportunity of gaining a higher degree, even fewer of the best brains in Britain than at present would train in technology. To attract men, technology must therefore have full university status as in

Europe and the United States, where the prestige of technologists is high. One argument used against a technological university is that it would deprive technological students of valuable social contacts with other students; but, in fact, the opposite is true. In the normal British university to-day, the demands of laboratory work keep students of technology from many student activities, whereas in institutions such as the Royal Technical College, Glasgow, which closely resembles a technological university college, all students are similarly placed and social activities easily arranged.

Another speaker observed that the idea of specialized technological institutions conflicts with an accepted definition of a university as a centre of general learning.

It was also pointed out that until greater administrative responsibility is given by industry to technologists, their status and numbers would remain unsatisfactory.

The value of postgraduate courses for young men from industry was stressed, and the popularity of such courses in the United States was mentioned. Among other matters raised was the function of the small technical college apparently threatened from below by the trades school and from above by the university.

In his replies, Prof. Baker agreed that on the Continent and in the United States public esteem for technology is high. That it is not so in Britain makes him doubt if lasting prestige would be gained by new 'technological universities'. On the present shortage of technologists, he maintained that the solution lies with industry to offer better opportunities to technologists and so induce more good entrants into the universities. While Cambridge-trained engineers are much sought after, many of them in the past had left the technical side of industry by the age of thirty. Speaking from recent experience in Cambridge, where a postgraduate course on "Structures and Materials" is available, he held that postgraduate courses for men back from industry are of great value. Advanced new knowledge can be applied to practical problems, and the results of research, which go unnoticed when published by learned societies, become available to industry without the distressing delay common in the past.

NEW BUILDINGS FOR THE DURHAM COLLEGES

AT a ceremony on May 15, at which the Warden of the Durham Colleges, Sir James Duff, presided, Prof. G. R. Goldsbrough, emeritus professor of mathematics in King's College, Newcastle upon Tyne (University of Durham), formally opened the West Building and the adjoining Applebey Lecture Theatre of the Durham Colleges. These buildings have been recently completed by the firm of Messrs. Leslie and Co., Ltd., to the designs of the architect, Prof. J. S. Allen, professor of town and country planning in King's College, Newcastle, and the consulting engineers, Dr. Oscar Faber and Partners. They form, with St. Mary's College, the first instalment of the plan for developing a new university centre on the south side of the city of Durham.

Already, some thirty years ago, the science laboratories had been erected in that neighbourhood; and when pressure upon the 'peninsula' site between the Castle and Cathedral became intolerable, it was decided to transfer the teaching of mathematics and geography to a new building adjacent to the laboratories which should contain also additional lecture rooms for all the sciences. Of this building, the Applebey Lecture Theatre (so named in honour of Dr. M. P. Applebey, sometime fellow and tutor of St. John's College, Oxford, and for the past fifteen years chairman of the Durham Colleges Council) forms the western wing. It accommodates an audience of 350 and is fully equipped with cinema projectors and all bench services; ventilation and lighting, which is entirely artificial, are under the lecturer's control. The demonstration bench and dais are removable to permit the use of the theatre for meetings, concerts and the less elaborately staged plays. Here, as in the smaller theatres, the walls are panelled with sound-absorbing material and the acoustics are excellent. By taking advantage of the slope of the ground on which the theatre stands, it has been found possible to provide beneath its gallery a large and lofty reading room with ample natural light and stack-room for some fifty thousand volumes.

At the opposite end of the building the eastern wing, adjacent to the existing laboratories, contains two lecture theatres, three lecture rooms of varying size, and private rooms for the staff of the Mathematics and Geography Departments. It is surmounted by a flat-topped tower with arrangements for mounting surveying instruments and a small telescope. The varied character of the rooms in this wing has needed careful planning; but by the use of mezzanines it has been possible to give each room its appropriate height. The wings are connected by a three-storied central range in which are seminar rooms for both mathematics and geography, a computing room, two laboratories for practical work in geography, a drawing office equipped for cartographical research, and a map library. The ground floor is occupied by a workshop, stores and ample cloak-room accommodation, while in the basement space is reserved for the installation of a wave tank.

Heating throughout is by concealed ceiling panels, connected to calorifiers which in turn receive heat from a central plant some two hundred yards away, recently erected to serve all University buildings in the area. All wires and pipes for the various services are concealed in a system of horizontal and vertical ducts which are readily accessible at a number of points in the building. There are no external rain-pipes, the roof water, when collected, passing down the vertical ducts.

The resulting 'tidiness' assists that simplicity of line which is perhaps the building's most pleasing characteristic. Except in the main entrance and staircase, where there is some elaboration of design and ornament, architectural decoration is almost entirely absent. Colour of great variety and richness has, however, been freely used. The predominant light grey of corridors and lecture rooms is relieved by the bright colourings of doors and windows. These vary from floor to floor: while geographers are plum-coloured, mathematicians are merely yellow! Some interesting experiments in colour have been made: the general hue of the Applebey Theatre is a mustard-yellow, while in the smaller theatres the deep indigo of the sound absorbers is in harmonious contrast with the subdued red of the ceilings. Colour is but one element in the prevailing impression of

airiness and light. The north front looks across the botanical garden to an unobstructed view of the Cathedral, half a mile away; on the south is a wooded hill. The architect has taken full advantage of these opportunities, and the beauty of the prospect from the reading room windows or from the balconies above the eastern entrance is a daily refreshment.

Externally, the central portion of the building and large parts of the eastern wing are brick faced with artificial stone; the large glass surfaces of the entrance halls, the main staircase and the library are striking features, and copper has been extensively used. The roof, all the copings and window-sills, as well as the outer walls and window mullions of the theatre, are of copper cladding, the total area of which amounts to about half an acre. Its use in conjunction with the galvanized steel of the window-frames has presented some problems of insulation. It may be well to add that all was purchased and in store before the rise in price and recent restrictions.

The building is surrounded by a nicely adjusted arrangement of lawns, pavements and cobble-stones; and on the south side, as a reminder of the imperfection attending all human achievement, is a projecting terrace ending in a turnip field, where it is hoped that sooner rather than later a companion block for the biological sciences will be built.

AGRICULTURE AND FORESTRY RESEARCH IN EAST AFRICA

THE East African Agriculture and Forestry Research Organization was established in 1948 to conduct basic research in the sciences bearing on agriculture and forestry, having developed from the East African Agricultural Research Station at Amani in Tanganyika Territory, and which itself was previously the old German research institute started in 1906 in a clearing in the forest in the Usambara Mountains. Long-range research work on an East African basis was begun at Amani in 1927, and the achievements of the small staff of never more than nine research workers during 1927–47 are described in a short account by Dr. H. H. Storey*.

The basic research work of Geoffrey Milne between 1929 and his death in 1942 placed our knowledge of East African soils on a sound basis and established for him an international reputation as a soil scientist. By 1935 he and his colleagues in the several Departments of Agriculture had gained sufficient knowledge of the soils to permit Milne to prepare a provisional map of East Africa. His conclusions on the nature of the soils studied were interpreted by him into recommendations for their proper use, and correct land use in East Africa derives much from principles enunciated in his writings. A reconnaissance report of his 1935–36 journey through Tanganyika Territory was published by the *Journal of Ecology* after his death. This journey covered part of the area recently developed by the Overseas Food Corporation, and the report has been a basis for soils work by the scientific staff of the Corporation.

Amani played an important part in the survey of the wild plants of East Africa. This work centred around the Amani Herbarium which, when taken over in 1928, contained about ten thousand dried specimens collected by expeditions of leading botanists from Germany during the nineteenth and early twentieth centuries. These collections contain many 'type' specimens, some of them the only 'types' existing, owing to the loss of duplicates in Europe during the Second World War. P. J. Greenway, the systematic botanist at Amani, has preserved and augmented this collection, which in 1950 contained seventy thousand specimens, and the Amani Herbarium was regularly visited by collectors and botanical expeditions from all over the world.

Investigations by the plant physiologists on the coffee plant led to the discovery of the effects of overbearing on the root system. As a result of F. J. Nutman's work, the coffee root system and something of how soil conditions and treatment affect it, the effect of carbohydrate starvation on the root system and cultural conditions which allow a maximum economic crop are known. The root system of sisal in relation to different soil conditions has also been studied.

Work on virus diseases of cassava led to a search for varieties resistant to mosaic disease and to extensive hybridization of cassava with other species of *Manihot*. In the study of plant diseases, the chief contribution made at Amani, under the inspiration of H. H. Storey, was fundamental research into the relationship between a virus, the plant and the insect that carried the disease. Means of controlling leaf-curl in tobacco and tea 'yellows' were developed as a result of basic research by Storey.

During the Second World War much of the long-term research work at Amani was discontinued. Staff were posted to other work and some direct war research was undertaken at the Station, including processes for large-scale extraction of quinine from cinchona bark, production of camouflage nets from sisal twine, making local dye for army tents from an extract of mangrove bark, devising a process for heat insulation of armoured fighting vehicles, development of a process for cracking vegetable oils to give petrol and kerosene substitutes, and a method of distilling camphor from the wood of *Cinnamomum camphora*.

In 1946 it was proposed at a conference in East Africa that all agricultural specialist officers and the research staff of Amani should be transferred to a new body which became the East African Agriculture and Forestry Research Organization†, situated at Muguga in a forest reserve of 1,600 acres near Nairobi, with Dr. B. A. Keen as director; Dr. Keen's services have been acknowledged by the honour of knighthood conferred recently in the Queen's Birthday honours list.

In the director's annual report for 1950‡ the construction of headquarters and the scientific work of the Organization are described. Fertilizer experiments which have been running for three years are showing results. Investigations on sudden-death of cloves in Zanzibar have not proved the virus hypothesis of transmission, and investigations have revived interest in possible fungus pathogens. The East African Herbarium has been moved from Amani to a new building in Nairobi, and the welding of the Coryndon Museum Herbarium of some twenty thousand sheets with the Amani collection has begun.

* Basic Research in Agriculture: a Brief History of Research at Amani, 1928–1947. By H. H. Storey. Pp. 24+7 plates.
† East African Agriculture and Forestry Research Organization: its Origin and Objects. By Dr. B. A. Keen. Pp. 12.
‡ East African Agriculture and Forestry Research Organization. Annual Report, 1950. Pp. ii+57.
(Kikuyu: East African Agriculture and Forestry Research Organization, 1951.)

LETTERS TO THE EDITORS

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An Antituberculous Substance in Tuberculous Lymph Nodes

THIS preliminary communication deals with the isolation from bovine tuberculous lymph-nodes of a substance which has an inhibitory effect on bovine and human tubercle bacilli.

Tuberculous lymph-nodes were reduced to pulp, and diluted in a proportion of 10 ml. of Sauton's medium to every 100 gm. of pulp. After seven to eight days at a temperature of + 4° C., the suspension was squeezed through gauze. The resultant fluid, which was viscous and opaque, was centrifuged until the supernatant was free from coarse particles and relatively clear. Seitz filtration was not used, because preliminary experiments suggested that part or all of the antituberculous property was lost by adsorption on the pad.

Bottles each containing 2 ml. of the extract were inoculated with 1 mgm. of tubercle bacilli, bovine type. The strain was of fairly high virulence, since 0·0001 mgm. regularly produced tuberculosis in guinea pigs in a six-week period. Some bottles were left at room temperature for periods of 48 hr., four days and seven days respectively. Others were incubated at 37° C. for 24 hr. and for 48 hr. Control suspensions prepared from tubercle bacilli suspended in saline solution were also exposed at room temperature and at 37° C. for similar periods of time. After incubation, all samples were then inoculated, each into two guinea pigs, and these were killed after six weeks. The extent of the tuberculous changes, where present, was estimated and an examination made for the presence of tubercle bacilli.

It was found that all the guinea pigs receiving the suspension in the extract kept either at room temperature for four or seven days or for 48 hr. at 37° C. were free from visible signs of disease, whereas controls inoculated with the saline suspension showed extensive generalized tuberculosis. Contact at 37° C. for 24 hr. or at room temperature for 48 hr. was not sufficient to inactivate tubercle bacilli. The extract of tuberculous lymph-nodes was equally active against a human strain (*H37Rv*).

In order to exclude the possibility that the tubercle bacilli were still living but were prevented from exerting a pathogenic effect through a protective coating of products of the lymph-node suspension, bacilli exposed to extract for six days at room temperature were washed three times with saline. Guinea pigs inoculated with the washed bacilli did not show any sign of tuberculosis when killed four weeks later; but those killed eight weeks later showed tuberculous lesions in the regional lymphatic nodes. Controls showed extensive lesions after four weeks and progressive tuberculosis after six weeks.

Tubercle bacilli suspended in extract and left at room temperature for seven days or at 37° C. for two days were examined microscopically. The organisms were aggregated into large clumps suggesting that they had been agglutinated. The staining properties, however, were not obviously altered.

Most of the observations on the activity of this tuberculous extract have been made on tubercle bacilli from cultures; but inactivation also occurred when the extract was allowed to act on bacilli present in the spleen and liver of the tuberculous guinea pig. A suspension in saline of spleen and liver from a tuberculous guinea pig showing large numbers of tubercle bacilli in each microscopical field was added to double the quantity of the extract and left at room temperature for seven days. A control suspension of the spleen pulp, in saline without extract, was treated in a similar manner. Each sample was inoculated into two guinea pigs, which were killed six weeks later. At post-mortem examination only the controls showed tuberculosis.

Preliminary experiments on the effect of the antituberculous substance on the growth of *H37Rv* on fluid media showed complete inhibition at a dilution of 1 : 50, and partial inhibition at 1 : 100. As the crude extract was not sterile, it was filtered four times through Kieselguhr and then through 'Gradocol' collodion membranes (0·68 μ), a process which might have considerably reduced the antituberculous activity.

Attempts to separate the antituberculous substance from the lymph-nodes of non-tuberculous cattle and from the spleen of a guinea pig failed to produce any substance which would inactivate a suspension of tubercle bacilli.

Sufficient experiments have not been undertaken to determine whether the agent present in lymph-nodes of the ox is a form of immune body, or whether it is similar to 'spermine' recently described by Hirsch and Dubos[1] as having an inhibitory action on tubercle bacilli. The value of extract-treated bacilli as an immunizing agent and the possible therapeutic value of the extract will be reported in a subsequent communication.

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[1] Hirsch, J. G., and Dubos, R. J., *J. Exp. Med.*, **95**, 191 (1952).

Action of some Water-soluble Poly-α-Amino-Acids on Bacteria

SOME of the antibiotics formed by fungi and bacteria have been found to consist of α-amino-acids linked by peptide bonds[1]. The recent work of Bloom, Watson, Cromartie and their associates[2] showed that even the cells of higher animals may, in certain circumstances, for example, in infection with anthrax, excrete antibacterial substances of peptide nature. These facts encouraged us to study the biological properties of some synthetic water-soluble poly-α-amino-acids, which were synthesized in this laboratory[3].

The water-soluble poly-amino-acids investigated may be classified, according to their electrochemical properties, into neutral, acidic and basic poly-amino-acids. In the present study, poly-DL-alanine was chosen as representative of the neutral poly-amino-acids (it is the only known water-soluble representative of this group); the acidic poly-amino-acids were represented by synthetic poly-L-aspartic acid and the natural poly-D-glutamic acid, and the basic ones by poly-L-lysine, poly-DL-lysine, poly-DL-ornithine and poly-DL-arginine.

It was found that the basic poly-amino-acids are able to inhibit the growth of Gram-positive and

Gram-negative bacteria (such as *Micrococcus pyogenes* var. *aureus*; *Escherichia coli*, *Bacillus anthracis*, *Pseudomonas aeruginosa*, *Shigella paradysenteriæ* Flexner, *Vibrio comma*, *Klebsiella pneumoniæ*, *Eberthella typhosa*, *Bacillus mesentericus* and *Bacillus subtilis*) grown on nutrient agar. The concentrations required for inhibition were 0·1–1·0 mgm. polypeptide per ml. agar solution. However, when *M. aureus*, *E. coli* and *B. anthracis* were grown in synthetic media, growth inhibition occurred even at a concentration of 1–15 γ basic poly-amino-acid per ml. medium.

It has been observed that the admixture of the basic poly-amino-acids with standard agar solution leads to the formation of a colloidal precipitate, and it seems likely that this insoluble complex is inactive towards bacteria, thus reducing considerably the concentration of the free synthetic polypeptide in the medium. This may be why higher concentrations of poly-amino-acids were necessary for inhibition on agar than on synthetic media.

The neutral and acidic poly-amino-acids did not interfere with the growth of the bacteria investigated on agar (even at a concentration of 10 mgm. peptide per ml. agar) or in synthetic media (even at a concentration of 500 γ peptide per ml. medium). Poly-L-lysine agglutinates living cells of *M. aureus* and *E. coli* at a concentration of 150 γ and 600 γ per ml. respectively.

Since lysine, ornithine and arginine monomers showed no inhibitory effect on bacterial growth, in the range of concentrations studied, it seems that the molecular weight of the basic polypeptides plays an important part in the determination of their antibacterial properties.

The interaction of the basic poly-lysine with bacteria at the bacteriostatic range seems to be reversible; thus it is possible to restore the growth of *E. coli*, previously incubated with the above basic polymers, by the addition of equivalent amounts of the acidic poly-amino-acids, poly-aspartic or poly-glutamic acid. The monomeric aspartic and glutamic acids did not restore growth under similar conditions. As it has been shown in other experiments that poly-lysine in aqueous solution forms insoluble salts with poly-aspartic and poly-glutamic acids, it is reasonable to formulate the following scheme for the growth restoration, by means of poly-aspartic acid, of bacteria incubated with poly-lysine:

$$\text{Bacterium} + \text{poly-lysine} = (\text{bacterium} \longleftrightarrow \text{poly-lysine})$$

$$(\text{Bacterium} \longleftrightarrow \text{poly-lysine}) + \text{poly-aspartic acid} = \text{bacterium} + (\text{poly-lysine} \longleftrightarrow \text{poly-aspartic acid}).$$

Most of our experiments were carried out at *p*H 7·4, at which most of the bacteria studied are negatively charged. It seems, therefore, that at least part of the attraction between the bacteria and the antibacterial polymers, as between the basic and acidic poly-amino-acids, is caused by electrostatic forces.

The basic poly-amino-acids resemble in their antibacterial properties the basic polypeptide isolated by Bloom *et al.*[2], and the protamines and histones which are also linear polypeptides of a relatively low molecular weight.

In view of the simple chemical structure of the synthetic poly-amino-acids and of the similarity, in some measure, of the antibacterial properties of some poly-amino-acids to those of natural antibiotic peptides, it appears possible that the elucidation of the mechanism of action of various water-soluble poly-amino-acids on bacteria may shed some light on the mechanism of action of natural peptide antibiotics.

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[1] Synge, R. L. M., *Quart. Rev.*, **3**, 245 (1949).
[2] Bloom, W. L., Watson, D. W., Cromartie, W. J., and Freed, M., *J. Infect. Dis.*, **80**, 41 (1947). Bloom, W. L., and Blake, F. G., *ibid.*, **83**, 116 (1948). Watson, D. W., Cromartie, W. J., Bloom, W. L., Kegeles, G., and Heckly, R. J., *ibid.*, **80**, 28 (1947). Watson, D. W., Cromartie, W. J., Bloom, W. L., Heckly, R. J., McGhee, W. J., and Weissman, N., *ibid.*, **80**, 121 (1947).
[3] Katchalski, E., "Advances in Protein Chemistry", **6**, 123 (1951).

A Relationship between Nicotinamide Methylkinase and Folic Acid

Reports have appeared on growth inhibition and production of fatty livers in rats, due to forced methylation of ingested compounds such as glycocyamine, cystine or homocystine, pyridine and nicotinamide[1,2]. The fatty livers caused by nicotinamide administration in large doses are known to be susceptible to the action of choline, while the growth inhibition is alleviated by methionine[1]. An involvement of folic acid in this nicotinamide metabolism would seem predictable on the basis of its well-known mediation in biological methylations[3]. The present work was undertaken to ascertain this relationship. The studies included the effects of methanol and of formate as well, since *in vivo* and *in vitro* observations have now established that methyl synthesis could occur from glycine *via* formate and that the reverse, namely, the degradation of labile methyl to formate, could also take place[4]. Folic acid is concerned directly in formate production from glycine[5] and in its utilization for serine synthesis (see ref. 3).

Adult mice (inbred Swiss strain), 25–30 gm. in weight, were maintained on a folic acid-free purified ration[3] with 15 γ per cent of vitamin B_{12}. Folic-acid deficiency was augmented by incorporation of 0·3 per cent iodinated casein in the ration, and could be inferred at the end of five weeks from observations on the hæmogram and the slight decline in weight. The animals were then divided into groups receiving as supplements folic acid (10 γ/mouse/day, orally) and/or methanol or formate (1 mgm./mouse/day, intraperitoneally) with necessary controls.

Urinary N^1-methyl nicotinamide was determined fluorimetrically[6] on the pooled urine samples of three mice from each group collected for 48 hr. on the eighth and ninth days of the experiment. This was followed by similar determinations after intraperitoneal administration of 1 mgm. of nicotinamide a day and an equilibration period of two days. For the determination of nicotinamide methylkinase activities, animals from each group were sacrificed at the end of 22, 27 and 31 days. The livers were quickly excised, chilled and homogenized with ice-cold Krebs–Ringer bicarbonate buffer of *p*H 7·2, the final volume being made up to 8·0 c.c. per gm. of liver (phosphate buffers were inhibitory). 1·5 c.c. of this homogenate plus 0·5 c.c. each of nicotinamide

(≡ 2 mgm.) and methionine (≡ 6 mgm.) solutions in bicarbonate buffer together with 1 c.c. each of 0·0015 *M* sodium fumarate and 0·01 *M* sodium citrate were incubated at 37° for 3½ hr. with frequent shaking. Reaction was stopped by addition of 0·3 c.c. of 100 per cent trichloracetic acid, and N^1-methyl nicotinamide was determined in 1-c.c. aliquots of the filtrate[6]. All values reported (see table) are means of at least three determinations and represent in each case increments after the incubation period over the zero-time digest prepared similarly; the results with methanol only as supplement to the basal ration with or without folic acid are given here.

Group	Urinary N^1-methyl nicotinamide (γ per 100 gm. body wt. for 24 hr.)		N^1-methyl nicotinamide synthesized (γ per gm. of liver)	Methionine disappearance (mgm. per gm. of liver in 3½ hr.)
	Basal ration	Basal ration plus 1 mgm. nicotinamide a day		
Basal (no folic acid)	6·0	69·2± 4·78*	15·2±1·79*	1·04±0·12*
Basal plus methanol	9·3	93·9±12·35	19·6±2·58	1·30±0·14
Basal plus folic acid	10·9	105·8±11·34	27·5±2·94	3·37±0·14
Basal plus folic acid plus methanol	10·1	110·0±10·50	20·5±1·60	2·89±0·68

* Standard error.

It is apparent that dietary folic acid influences both *in vitro* and *in vivo* methylation of nicotinamide. That this effect is in part at least attributable to a check on drain of methyl to formate is observable from the results with the folic acid-deficient group supplemented with methanol, the latter presumably exerting its effect through mass action. The possibility that the methanol may also contribute to methyl neogenesis would not seem excluded in view of other observations (unpublished) that folic acid does not specifically catalyse this synthetic step. The impairment of creatine metabolism in folic-acid deficiency[3] is also partially restored by intraperitoneal dosages of formate or methanol (unpublished results).

The values for the disappearance of methionine were obtained as follows: 1 c.c. of liver homogenate (1 : 10 in phosphate buffer of *p*H 7·4) was incubated at 37° with 1 mgm. of methionine in 1 c.c. of buffer. Reaction was stopped after 3½ hr. with 0·2 c.c. of 100 per cent trichloracetic acid, and the residual methionine was determined in the filtrate. The results (see table) are not in accord with the conclusions of Dinning *et al.*[7] on folic acid-deficient and replete chicks; they are, however, analogous to the observations of Rienits[8] on the stimulation by folic acid of the disappearance of tyrosine from liver preparations of scorbutic guinea pigs.

Essentially similar though less pronounced results were obtained in the groups receiving a formate supplement; methanol as a precursor for methyl is known to be better than formate[4]. In other groups which received vitamin C in addition (1 mgm./mouse/day), there was a noticeable augmentation in the *in vivo* synthesis of N^1-methyl nicotinamide; this is evidently to be ascribed to potentiation of folic-acid activity in forming folinic acid[9].

We are extending the investigation to a study of the influence of folic acid on the depletion of methyl in rat livers consequent on forced ingestion of excessive amounts of nicotinamide.

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[1] Handler, P., *J. Biol. Chem.*, **154**, 203 (1944).
[2] Dinning, J. S., Keith, C. K., Parsons, J. T., and Day, P. L., *J. Nutrit.*, **42**, 81 (1950).
[3] Fatterpaker, P., Marfatia, U., and Sreenivasan, A., *Nature*, **167**, 1067 (1951).
[4] See du Vigneaud, V., Verly, W. G. L., Wilson, J. E., Rachele, J. R., Ressler, C., and Kinney, J. M., *J. Amer. Chem. Soc.*, **73**, 2782 (1951). Arnstein, H. R. V., *Biochem. J.*, **48**, 27 (1951).
[5] Trotter, J. R., Kelley, B., Day, P. L., and Edwards, R. R., *J. Biol. Chem.*, **186**, 145; **187**, 529 (1950).
[6] See Cantoni, G. L., *J. Biol. Chem.*, **189**, 203 (1951).
[7] Dinning, J. S., Keith, C. K., and Day, P. L., *J. Biol. Chem.*, **189**, 515 (1951).
[8] Rienits, K. G., *J. Biol. Chem.*, **182**, 11 (1950).
[9] Nichol, C. A., and Welch, A. D., *Proc. Soc. Exp. Biol. and Med.*, **74**, 52, 403 (1950).

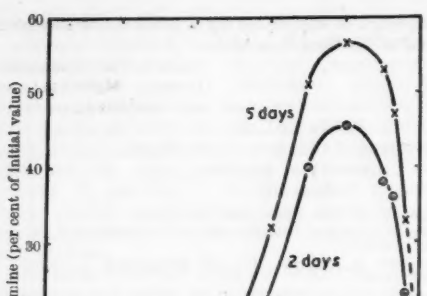
A Reaction of D-Glucosamine in the Presence of 'Dry' Protein

IN work on the reaction of reducing sugars with proteins in the 'dry' state already reported[1], glucosamine (2-amino-D-glucose) was used as an aldo hexose modified at the important carbon 2 position. Browning of the reaction mixture was found to occur extremely rapidly; but the chemical data indicated that something quite different from the normal protein amino group – sugar aldehyde group type of condensation[2] was taking place.

Further investigation has shown that glucosamine, when freeze-dried from a mixed solution of its hydrochloride with casein at *p*H 6·3 and stored at 37° C. and 70 per cent relative humidity, undergoes a rapid and extensive reaction in which the amino and aldehyde functions of the glucosamine molecule are simultaneously destroyed. The expected condensation of the aldo-sugar with the lysine ε-amino groups of the protein does not occur to any appreciable extent, and the lysine remains unaffected. The glucosamine reaction is accompanied by a marked browning of the material, and the free acid released as the basic amino groups are destroyed depresses the *p*H and renders the protein insoluble in the region of its isoelectric point (*p*H 4·6). As with the amino-aldehyde reactions already investigated[2,3], the rate shows a striking dependence on the water-content of the material, being very slow in the dry solid or in aqueous solution and reaching a maximum at an intermediate water content corresponding in this case to a relative humidity of 80 per cent (see graph).

When aqueous solutions of glucosamine hydrochloride, which had been adjusted to *p*Hs between 5·1 and 9·2 and contained therefore amounts of the free base ranging from 0 to 100 per cent, were dried and stored at 37° C. and 70 per cent relative humidity, an extremely rapid disappearance of glucosamine (as measured by the Elson and Morgan method[4]) occurred. This reaction ceased when all the free base had been used up. At *p*H 6·3, however, only 0·5 per cent of the base is free, and the mixture is correspondingly stable.

Glucosamine is therefore destroyed on drying and storing with protein at a *p*H at which it would be



Destruction of glucosamine in a freeze-dried casein–glucosamine mixture of initial *p*H 6·3 when stored for two and five days at 37° C. and various relative humidities

expected to be stable, the protein in the semi-dry state apparently neutralizing the hydrochloric acid and leaving the free base to react in the water film on the protein surface.

A comparable phenomenon was observed when N-acetyl-D-glucosamine was dried and stored in the same way with casein. After storage the reaction product was found to react in the Morgan and Elson method for N-acetyl-glucosamine[5] *without* the preliminary treatment with alkali, to give a colour spectroscopically identical with that obtained in the normal method. This indicates that the isomerization and condensation to the oxazole ring, which is usually brought about by boiling with 0·5 *N* sodium carbonate, had proceeded on the surface of the 'dry' protein.

In both these reactions the surface of the protein appears to have provided a more alkaline environment than would be expected from the *p*H of the solution from which it was dried. Such factors must obviously be included in consideration of deterioration of the browning type in dried foodstuffs, where degradation and caramelization of carbohydrate frequently occurs under conditions of *p*H at which the sugars alone would be stable.

Attention should also be directed to the possibility of destruction, by routes similar to that described, of 2-amino sugars during isolation procedures, especially if solutions are evaporated to dryness even at moderate temperature. Losses of chondrosamine (2-amino-D-galactose) have, for example, been observed during separation from hydrolysates by the use of anion exchange columns[6], and other cases of loss of amino-sugars have been reported in the literature[7].

The nature of the products from the glucosamine reaction is at present under investigation; a major component probably results from the condensation of two molecules of the α-amino aldehyde to form a pyrazine derivative, but several substances are present, some of them dark coloured.

This work was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. A full account will be published elsewhere.

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[1] Lea, C. H., and Rhodes, D. N., *Biochim. Biophys. Acta* (in the press).
[2] Lea, C. H., and Hannan, R. S., *Biochim. Biophys. Acta*, **3**, 313 (1949); *Biochem. J.*, **47**, 626 (1950). Schwartz, H. M., and Lea, C. H., *Biochem. J.*, [**50**, 713 (1952)].
[3] Hannan, R. S., and Lea, C. H., *Biochim. Biophys. Acta* (in the press).
[4] Elson, L. A., and Morgan, W. T. J., *Biochem. J.*, **27**, 1824 (1933).
[5] Morgan, W. T. J., and Elson, L. A., *Biochem. J.*, **28**, 988 (1934).
[6] Partridge, S. M. (private communication).
[7] Meyer, K., "Advances Protein Chem.", **2**, 256 (1944).

Populations of *Agrostis tenuis* Resistant to Lead and Zinc Poisoning

In order to find out on how small a scale ecological differentiation can occur, a study is being made of the differentiation in the grass *Agrostis tenuis* in the region around Aberystwyth. Samples of sixty separate tillers taken at random from each of a number of different habitats have been cultivated, suitably laid out in trial, in an experimental garden. A considerable amount of very local differentiation has been found, an account of which will be published elsewhere.

Of the populations sampled, one was from a disused lead mine known to be at least a thousand years old at Goginan, five miles from Aberystwyth, and another from an ordinary *Agrostis-Festuca* pasture a short distance away. The soil of the mine contains approximately 1 per cent lead and 0·03 per cent zinc mostly as sulphate and sulphide and carries no plant life except *Agrostis tenuis*. The pasture is uncontaminated. On cultivation in normal soil, the sample from the mine is distinctly smaller and grows more slowly. On being transplanted as tillers into soil from the mine, the mine sample grew normally while the pasture sample made no growth at all, 50 per cent of the tillers being more or less dead in three months. The latter were found to have produced misshapen roots rarely more than 2 mm. long, whereas the former rooted normally. These results were obtained immediately after the initial collection and again after the material had been in cultivation in normal soil for two years. There was no indication of any change in resistance having taken place. The character is practically restricted to the mine population, for only three plants of the pasture sample of sixty showed any real resistance though collected only a hundred yards away.

Further work on this and related population problems is being continued; the genus is being studied from the point of view of taxonomy, cytology and breeding by W. E. Davies, K. Jones and A. Lazenby of the Welsh Plant Breeding Station, Aberystwyth.

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Relation of Nitrogen Supply to the Molybdenum Requirement of Cauliflower Grown in Sand Culture

THE possible need for molybdenum by higher plants supplied with nitrogen in a form other than nitrate was first indicated by Arnon[1], who obtained improved growth of barley plants in the presence of a solution containing chromium, molybdenum and nickel with an ammonium nitrogen supply. Vanselow and Datta[2] and Hewitt[3] later showed the need of molybdenum by plants with adequate ammonium and nitrate nitrogen. Hewitt, however, has stated[3] that the absolute need for molybdenum for normal development when higher plants are supplied with ammonium nitrogen only still remains to be shown, and that the experimental difficulties of the use of ammonium compounds alone limit progress. Incorporation of solid calcium carbonate into ammonium nitrogen cultures, however, has been shown greatly to reduce the injury due to ammonium[4,5]. This device has been successfully applied to molybdenum-deficiency cultures using a purified source of calcium carbonate.

Cauliflower plants (var. Majestic) were grown in sand cultures at deficiency-levels of molybdenum of 0·00001 and of 0·00005 p.p.m., a normal level of 0·5 p.p.m. and an excess level of 50 p.p.m., with nitrogen at 10 m.*M*/lit. as follows: (i) nitrate without calcium carbonate, (ii) nitrate with calcium carbonate, (iii) nitrate with citric acid, (iv) ammonium sulphate with calcium carbonate, (v) ammonium citrate, (vi) ammonium nitrate, (vii) urea, and (viii) nitrite. Treatments with ammonium sulphate without calcium carbonate were included in the original scheme, but the plants did not make healthy growth and hence the effects of the treatments are not discussed in detail. Each compound was purified as previously described[6], and the analyses of dried foliage showed that molybdenum had been effectively removed for the deficiency-treatments.

Nitrate produced the best growth at the normal molybdenum level, but the plants with other treatments were sufficiently vigorous to show beyond reasonable doubt the effects of molybdenum-deficiency. The relative yields at 0·00001 p.p.m. molybdenum (approximately) as percentage of yields at 0·5 p.p.m. were (in the order given above): (i) 15·0, (ii) 15·2, (iii) 19·3, (iv) 36·3, (v) 24·8, (vi) 6·7, (vii), 21·4, (viii) 64·6. Leaf malformation and the bleaching and perforation of young leaves characteristic of whiptail[7,8] were observed at 0·00001 and 0·00005 p.p.m. molybdenum in all nitrogen treatments except nitrite. Typical advanced stages of whiptail in large plants[7] were characteristic of nitrate treatments and were accentuated by citric acid. Death of the growing point occurred with nitrate, ammonium nitrate, ammonium citrate and urea. 0·00005 p.p.m. molybdenum was sufficient to prevent any whiptail in the ammonium sulphate plus calcium carbonate treatment. Histological examination of some whiptail plants showed that the cells were not joined together and the middle lamella was almost invisible. This suggests that abnormal metabolism of pectic substances may be involved in the problem.

The ascorbic acid status was examined, and the effects reported previously[9,10] were confirmed. The relative ascorbic acid levels as percentage of the normal molybdenum levels at 0·00001 p.p.m. molybdenum were: (i) 58, (ii) 57, (iii) 79, (iv) 50, (v) 45, (vi) 58, (vii) 36, (viii) 67. Excess molybdenum did not further increase the ascorbic acid content over the normal treatment[9,10], and the molybdenum status did not materially affect the ratio of ascorbic to dehydroascorbic acid[10]. This and the overall response with different nitrogen sources support the suggestion of Hewitt *et al.*[9] that it may be in the synthesis of ascorbic acid or its precursors that molybdenum plays a part, rather than in its equilibrium in the oxidation-reduction systems.

Tests at intervals showed that nitrate was present in sand or accumulated in the foliage *only* when given in the treatment. This fact, and the characteristic appearance of plants grown with the other nitrogen sources, support the conclusion that the ammonium-, nitrite- and urea-nitrogen entered the plant without appreciable nitrification. Contrary to the effect of molybdenum deficiency on nitrate accumulation, no nitrite accumulated under similar conditions or in any other treatments. There was, on the other hand, a low concentration of ammonium-nitrogen present in the tissues of plants from all treatments.

Not only did the source of nitrogen interact with molybdenum at deficiency-levels, but the effects of the excess level also depended on the type of the nitrogen compound. Thus whereas with nitrate or ammonium nitrate and ammonium sulphate with calcium carbonate the toxicity effect was slight, injury was acute with ammonium citrate, urea or ammonium sulphate without calcium carbonate, the last treatment producing acute yellow intervenal chlorosis.

The effect of nitrite in relation to molybdenum deficiency was perhaps the most striking feature of these results, as this compound has shown the lowest molybdenum requirement so far with respect to growth, ascorbic acid status and freedom from whiptail. The implication of the results and a full account of the work described will be presented elsewhere.

The investigation was carried out under the guidance of Dr. E. J. Hewitt, to whom I am indebted for criticism and helpful suggestions.

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[1] Arnon, D. I., *Soil Sci.*, **44**, 91 (1937).
[2] Vanselow, A. P., and Datta, N. P., *Soil Sci.*, **67**, 363 (1949).
[3] Hewitt, E. J., "Ann. Rev. Plant Physiol." **2**, 25 (1951).
[4] Mazé, P., *Ann. Inst. Pasteur*, **28**, 21 (1914).
[5] Hewitt, E. J. (unpublished data, 1950).
[6] Hewitt, E. J., and Jones, E. W., *J. Pomol. Hort. Sci.*, **23**, 254 (1947).
[7] Hewitt, E. J., and Agarwala, S. C., *Nature*, **167**, 733 (1951).
[8] Hewitt, E. J., and Bolle-Jones, E. W., *J. Hort. Sci.*, (in the press).
[9] Hewitt, E. J., Agarwala, S. C., and Jones, E. W., *Nature*, **166**, 1119 (1950).
[10] Agarwala, S. C., Ann. Rep. Long Ashton Res. Sta. (1951).

A Tea Root Disease New to South India

DURING a visit to some estates in Central Travancore in October 1951, my attention was directed to a small patch of unthrifty tea on one of the estates. The bushes appeared 'thin', with weak development of the branches and only a crown of unhealthy foliage. Examination of the aerial parts did not reveal any sign of insect damage or fungal attack. The roots, however, showed certain characteristic symptoms, namely, the entire absence of feeding roots and the presence of circular or slightly elongated and raised patches all over the bark of the tap and lateral roots (see photograph), and also extending to

Portion of tea root showing the lesions caused by a species of *Cylindrocladium*

the collar—a feature not associated with any of the known root diseases of tea. The lesions varied in size from minute spots to small patches measuring 2–15 mm. across. The discoloration of the bark in the affected regions extended to a few cells only in the case of the small spots, while in the larger lesions the entire depth of the bark was affected and the wood too was occasionally seen to be discoloured just below the necrotic area on the bark. In some cases the affected bark had fallen off leaving a shallow scar or depression on the root surface. These external symptoms agreed to some extent with the verbal description of a *Plasmodiophora* root disease of tea reported from Assam in 1948 (private communication from the Directorate of Plant Protection, Ministry of Agriculture, Government of India). As no species of *Plasmodiophora* was evident in the South Indian material, it was sent to the Commonwealth Mycological Institute, Kew, for examination. While confirming the absence of *Plasmodiophora*, an apparently distinct species of *Cylindrocladium* was reported as being associated with the lesions on the root. Since sending the material to Kew, I have been able to isolate the fungus from the small spots on the diseased roots.

The genus *Cylindrocladium* was first recorded from India in 1945 on the leaves of ***Ficus carica***[1]. The present instance on tea appears to be a new record of the genus on this host from this country. A similar fungus seems to have been reported on tea from Nyasaland (private communication from the Commonwealth Mycological Institute, Kew), and it was also recently observed on tea in Ceylon[2]. The Ceylon species is said to be similar in morphological characters to that causing a shoot wilt of plum and cherry rootstocks in the United Kingdom (that is, *C. scoparium*). A preliminary study of the South Indian species grown on the original infected root material under sterile conditions and on an artificial medium shows that it differs from *C. scoparium* in some morphological characters. Also it does not seem to agree with a few other described species[3,4], but further study is no doubt necessary to establish its specific identity.

The diseased patch is situated on the bank of a river, the water table apparently being fairly high for most parts of the year. Whether this feature, not usually met with in South India, favours the activities of the fungus has yet to be determined. The soil is a sandy loam, acidic in reaction (the *p*H values being 6·12 and 4·96 for the top- and sub-soils) and, in general, suitable for the normal growth of tea. It is not known whether this fungus is a weak parasite, like *Botryodiplodia theobromæ*, invading the roots of bushes debilitated by other causes, or a primary pathogen like *Cylindrocladium scoparium* reported on plum[5,6], cherry[5], strawberry[7], and *Eucalyptus* spp.[8,9]. As a precautionary measure, to eliminate infectious material from the diseased area so far as possible, the estate concerned has been advised to uproot and burn on the spot all the affected bushes in that small patch. Should the disease spread further and the fungus prove to be a primary pathogen capable of free spread through the soil, or with potentialities for saprophytic existence, as in the case of some species of *Fusarium*[10,11], it may be necessary to adopt other control measures. The fungus and its behaviour are being studied further.

I am grateful to Dr. S. P. Wiltshire and Mr. B. N. Webster, Commonwealth Mycological Institute, Kew, for examining the material and identifying the fungus. My thanks are also due to Messrs. M. C. A. Jackson and W. A. J. Milner for bringing this root-infecting fungus to my notice, and to Messrs. Peter de Jong, S. Ananda Rau and V. Jayaraman for their helpful criticisms in the preparation of this note.

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[1] Mehta, P. R., and Bose, S. K., *Ind. J. Agric. Sci.*, **17**, 219 (1947).
[2] Loos, C. A., Tea Res. Inst. Ceylon, Ann. Rep. for 1949, *Bull.* 31, 42 (1951).
[3] Sherbakoff, C. D., *Phytopath.*, **18**, 219 (1928) (*R.A.M.*, **7**, 508).
[4] Boedijn, K. B., and Reitsma, J., *Reinwardtia*, **1**, 51 (1950) (*R.A.M.*, **30**, 345).
[5] Wormald, H., *J. Pomol.*, **20**, 80 (1943) (*R.A.M.*, **23**, 30).
[6] Vanderwalle, R., *Parasitica*, **5**, 5 (1949) (*R.A.M.*, **28**, 527).
[7] Truscott, J. H. L., *Canad. J. Res.*, **11**, 1 (1934) (*R.A.M.*, **13**, 785).
[8] Arruda, S. C., *Biológico*, **9**, 140 (1943) (*R.A.M.*, **22**, 505).
[9] Jauch, C., *Rev. argent. Agron.*, **10**, 355 (1943) (*R.A.M.*, **23**, 135).
[10] Sadasivan, T. S., *Ann. App. Biol.*, **26**, 497 (1939).
[11] Subramanian, C. V., *J. Ind. Bot. Soc.* (M.O.P. Iyengar Commem. Vol.), 209 (1946).

The Brown Alga *Durvillea antarctica* in Australian Waters

The massive brown alga *Durvillea antarctica* (Cham.) Hariot has recently been found washed up in three different places on the Australian coast. Miss Alison Baird, of the University of Western Australia, has informed us that a piece, 8–9 cm. long, of an almost cylindrical thong-like segment was found in drift at Nornalup on the south coast, about seventy miles west of Albany, in December 1947. A similar piece was included in a display of New Zealand seaweeds at the Hobart meeting of the Australian and New Zealand Association for the Advancement of Science in January 1949; on that occasion one of us (L. B. M.), in company with Miss Baird, collected from drift at Taroona, on the west side of the Derwent Estuary below Hobart, a partly decomposed fragment of about the same dimensions. In February 1950, the other (A. B. C.) found a plant 2 m. long and only lacking the holdfast at Port Arthur on the east coast of Tasmania; most of it was in good condition, though it bore a heavy growth of barnacles (*Lepas* sp.), which may indicate that it had been floating for some time. A portion of it has been compared with New Zealand *D. antarctica*, which it matches well.

This species has not hitherto been recorded from any part of Australia. On the coasts of Tasmania, Victoria, and southern New South Wales, the ecological equivalent is *D.* (*Sarcophycus*) *potatorum*, which, however, has solid fronds, like *D. willana*[1] in

New Zealand. *D. antarctica* is known from Valparaiso to Cape Horn and up to about 50° S. lat. on the east coast of South America, from the Strait of Magellan, from the Falkland Islands, from drift (but not certainly growing) at South Georgia, and from Kerguelen[2]; it is abundant in suitable habitats around the coast of New Zealand and its outlying islands. The central layers of its divided leathery blade are occupied by a series of air-chambers so that the fronds float on the surface of the extremely turbulent waters where this species characteristically grows. Skottsberg[3], referring to fragments of *D. antarctica* cast ashore on Deception Island where it has not been found growing, says that they may have been carried down from Fuegia during north-west gales, or have come from New Zealand with the west-wind drift. The three new records suggest that *D. antarctica* may yet be found growing on out-of-the-way parts of the Australian coast, although it is quite possible that the pieces found had floated very long distances. The nearest source to the west is Kerguelen, more than five thousand miles away.

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[1] Lindauer, V. W., *Pac. Sci.*, **3**, 348 (1949).
[2] Skottsberg, C., "Wissensch. Ergebn. der schwed. Südpolar-Expedition 1901–1903", **4**, 141 (1907).
[3] Skottsberg, C. K., *Svensk. Vetensk. Handl.*, 3rd Ser., **19** (4), 48 (1941).

Autolysis of Flight Muscles in a Mosquito

During July 1951 a number of specimens of gravid female mosquitoes, in which the flight muscles showed various degrees of autolysis, were collected in the vicinity of Churchill, Manitoba. The loss of scales and hairs renders identification of a mosquito of this group impossible by means of conventional characters. There is good circumstantial evidence, however, that all these specimens were either *Aedes communis* De Geer, or an as yet undescribed species indistinguishable from it on any single morphological character in the larval or adult stage[1].

Whatever its identity, in this area at least, it is doubtful if this species ever takes a blood meal. About twenty specimens were examined, and there was good inverse agreement between the degree of egg development and the degree of breakdown of flight muscle. Specimens in which the eggs were almost ready to be laid showed no trace of either tergo-sternal or dorsal flight muscles, the mesothorax thus appearing almost completely devoid of solid structures. The number of eggs developed ranged from 43 to 91, with an average of 64. All specimens were taken by sweeping with a heavy net in vegetation close to the ground, and most of them not far from the margins of pools in which the larvæ of these species develop.

It seems clear that this species must become a flightless insect very soon after egg development commences. This would explain the failure to capture gravid females in the field in previous seasons. It also agrees well with the observations of Jenkins and Hassett[2] indicating a very limited dispersal range for this species complex. Preliminary observations suggest that the nitrogen content of the flight muscles is roughly equivalent to that of about sixty eggs, and it appears unquestionable that this represents a parallel to the situation reported in ants by Wheeler[3], the nitrogen of the flight muscles being utilized in the production of eggs. A fuller account of these observations will be published elsewhere.

I am indebted to Mr. G. S. Eligh, Division of Entomology, Department of Agriculture, Kingston, Ontario, who brought in the first specimens, taken during a search at Churchill, Manitoba, for blood-engorged females, and to the Canadian Defence Research Board, Ottawa, and the Division of Entomology, Ottawa, which provided the opportunity for this material to be studied.

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[1] Hocking, B., Richards, W. R., and Twinn, C. R., *Can. J. Res.*, D, **28**, 58 (1950).
[2] Jenkins, D. W., and Hassett, C. C., *Can. J. Zool.*, **29**, 178 (1951).
[3] Wheeler, W. M., "The Social Insects", 169 (Kegan Paul, London, 1928).

The Bent Excited State of Acetylene

The band systems of C_2H_2 and C_2D_2 at 2400–2100 A. have been studied in absorption, and the vibrational and resolved rotational structures fully analysed. It emerges that, in its excited state, acetylene is a plane centrosymmetric zig-zag (like ethylene from which two trans-related hydrogen atoms have been removed). It is therefore an asymmetric top. Its dimensions in the lowest vibrational level of that state are CC = 1·383 A., CH = 1·08 A., ∠CCH = 120·2°. The frequency of the CC stretching vibration is 1,385 cm.$^{-1}$ in C_2H_2 and 1,300 cm.$^{-1}$ in C_2D_2, the derived mean force-constant being $F = 7{\cdot}2 \times 10^5$ dyne/cm.; while the vibration which together opens the angles has the frequency 1,049 cm.$^{-1}$ in C_2H_2 and 835 cm.$^{-1}$ in C_2D_2, the corresponding mean bending-force-constant being $\delta = 8{\cdot}5 \times 10^{-12}$ dyne.-cm./radian. The electronic wave function has the two-fold axis and plane, but not the centre of symmetry of the zig-zag molecule. The lowest vibrational level of this bent excited state lies at 42,209 cm.$^{-1}$ in C_2H_2 and at 42,280 cm.$^{-1}$ in C_2D_2, above that of the linear normal state, the difference of 71 cm.$^{-1}$ arising from differences in zero-point vibrational energy. In the transition from the normal to the excited state, the electrons oscillate perpendicularly to the plane of the bent molecule. The resultant electron-spin remains zero. The transition probability, expressed as an oscillator strength, is 8×10^{-5}. All this follows from the analysis of the spectra.

Molecular orbital theory indicates that the lowest electronically excited state to which transition is allowed should be of the described symmetry. The σ-bond hybridization is plane-trigonal (as in ethylene or benzene), and there is otherwise one π-orbital in the CC-bond for shared electrons, and one non-bonding orbital on each carbon atom for unshared electrons, not to mention many more highly energized orbitals. After the completion of the σ-bond system, four electrons remain, which are insufficient to fill the π-bonding and the two non-bonding orbitals up to the limit allowed by the Pauli principle. In the

lowest metastable state the defect is spread: one shared electron enters the π-orbital (though there is room for two), while three unshared electrons occupy the non-bonding orbitals (where there is room for four). The CC bond is thus a three-electron bond. Hence it can be understood that, while the angle is the same as in either normal ethylene or benzene (120°), the lengths are practically identical with those in benzene (usually given as CC = 1·39 A., CH = 1·08 A.), and the force-constants markedly resemble those of benzene (recorded[1] as $F = 7{\cdot}6 \times 10^5$ dyne/cm., $\delta = 8{\cdot}0 \times 10^{-12}$ dyne-cm./radian).

This first precise elucidation of a marked change of molecular shape on electronic excitation may be indicative of a common phenomenon in excitations of simple π-electron systems[2].

Some of the weaker bands were measured with a multiple reflexion cell kindly lent by Dr. W. C. Price. The analysis was aided by discussions with Prof. R. Mecke and Dr. G. Herzberg, and by many with Prof. D. P. Craig. We thank these friends for their help.

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[1] Garforth, Ingold and Poole, *J. Chem. Soc.*, 508 (1948).
[2] Cf. Mulliken, *Phys. Rev.*, **60**, 506 (1941).

Polarization of the Second Ultra-violet System in Hexamethylbenzene

Allowed electronic transitions in aromatic molecules between states approximately described by combinations of $p\pi$ atomic orbitals must all be polarized in the molecular plane, and the same is true of the much weaker transitions which take on allowed character only because of the disturbing effect of nuclear vibrations. This is the polarization property actually found in band systems so far studied experimentally, almost all of which have been lowest-energy transitions. Specifically, Scheibe[1] showed that the 2800-A. system of hexamethylbenzene is polarized with the active electric vector in the molecular plane. This system certainly corresponds to the well-known 2600 A. system of benzene itself, which is assigned $A_{1g} - B_{2u}$ from vibrational analysis. Hexamethylbenzene crystallizes with all the molecular planes parallel to one another, and perpendicular to the main faces of a sublimed crystal, and so is much better suited to polarization measurements than benzene.

In the upward sequence of excited states, corresponding to band systems at higher energies and shorter wave-lengths, it is to be expected that new types of atomic orbitals will be needed in the approximate molecular wave functions. Thus atomic *ns* and *np* orbitals are required in the upper states of the vacuum ultra-violet transitions studied in benzene by Price and Wood[2]; and in discussing the question which of the observed band systems is the lowest in which *s* atomic orbits participate, Hammond, Price, Teegan and Walsh[3], affirming in more specific terms an assignment made earlier by Carr and Stücklen[4], proposed that the second benzene system, that at 2000 A., was the lowest such Rydberg transition, implying that its polarization is perpendicular, and not parallel, to the molecular plane.

We have now studied the polarization of the 2300-A. system of hexamethylbenzene, which corresponds to the 2000-A. system in benzene, and find that the electric vector lies in the molecular plane, just as in the long wave-length system. Measurements of the extinction ratio in the two polarizations show that absorption perpendicular to the molecular plane, while not necessarily zero, is less than ten per cent of that in the plane. Applied to benzene, these results indicate that the 2000-A. system is polarized predominantly in the molecular plane. It remains possible that the first *ns* Rydberg band system underlies the 2000-A. absorption, even though this does not appear to be true in hexamethylbenzene, but is very much weaker than hitherto supposed; alternatively, it may fall elsewhere in the spectrum. Polarization in the molecular plane is, however, consistent with the assignment of the upper state of this system to a π-electron state, whether this be the B_{1u} state as originally suggested by Goeppert-Mayer and Sklar[5] or the E_{2g} state as proposed more recently by one of us[6].

The polarization measurements were made with a Hilger medium quartz spectrograph. A selected calcite rhomb, transparent to 2150 A., was mounted immediately behind the slit and the crystal of hexamethylbenzene (a sublimation flake between silica disks) placed before it on a rotating stage. Each exposure gave two adjacent images, corresponding to two directions of plane-polarization. One such exposure is shown in the accompanying photograph.

2400 A. 2200 A.

Hexamethylbenzene photographed through a calcite rhomb. The upper beam is polarized in the molecular plane, the lower perpendicular to it

Comparison of the two images from a single exposure gives an immediate though rough indication of polarization properties; but to avoid discrimination within the spectrograph and for other reasons, we actually used one beam at a time, rotating the crystal between exposures and comparing the results with the crystal structure[7] interpreted by a study of the same crystal with the polarizing microscope.

This work will be published more fully, with a discussion of its theoretical implications. We thank Dr. P. G. Owston for important aid in microscopy, and for many helpful discussions.

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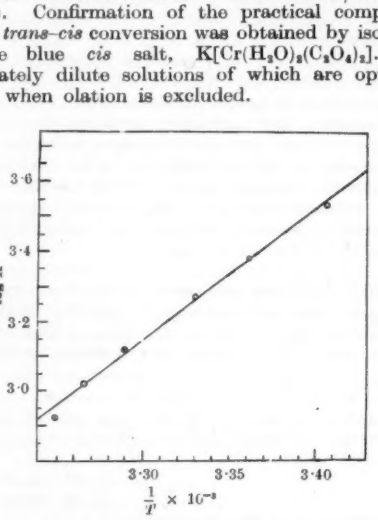
[1] Scheibe, G., Hartwig, St., and Muller, R., *Z. Electrochem.*, **49**, 372 (1943).
[2] Price, W. C., and Wood, R. W., *J. Chem. Phys.*, **3**, 439 (1935).
[3] Hammond, V. J., Price, W. C., Teegan, J. P., and Walsh, A. D., Disc. Farad. Soc., **9**, 53 (1950).
[4] Carr, E. P., and Stücklen, H., *J. Chem. Phys.*, **7**, 631 (1939).
[5] Goeppert-Mayer, M., and Sklar, A. L., *J. Chem. Phys.*, **6**, 645 (1938).
[6] Craig, D. P., *J. Chem. Phys.*, **17**, 1358 (1949).
[7] Brockway, L. O., and Robertson, J. M., *J. Chem. Soc.*, 1324 (1939).

Potassium Dioxalato Diaquo Chromium (III) Complexes: *Trans–Cis* Isomerization

THE X-ray diffraction data of van Niekerk and Schoening[1], obtained from a sample of red potassium chromi oxalate prepared in these laboratories and corresponding analytically to $K[Cr(H_2O)_2(C_2O_4)_2].3H_2O$, led these workers to affirm that this salt has the *trans* configuration, as deduced by Werner[2] from other evidence. We have investigated the colour and other changes which occur when aqueous solutions of this salt are aged under different conditions, and our results show that the changes are due to *trans–cis* isomerization, uncomplicated by olation phenomena. Since the same ultimate molar extinction coefficient is attained over a wide range of temperature and concentration, we conclude that the transformation to the *cis* configuration proceeds to practical completion. Kinetically, the reaction obeys a first-order law, and the dependence of the observed velocity constant upon temperature is found to be adequately described by the Arrhenius equation, where $A = 3 \times 10^9$ and $E = -17{\cdot}9$ k.cal./mol. (see graph). Confirmation of the practical completion of the *trans–cis* conversion was obtained by isolation of the blue *cis* salt, $K[Cr(H_2O)_2(C_2O_4)_2].2H_2O$, moderately dilute solutions of which are optically stable when olation is excluded.



For our investigations we employed the potassium *trans* salt prepared by Croft's method[3] and purified by digesting in 1 per cent nitric acid (to destroy traces of potassium trioxalato chromiate) prior to recrystallization. The corresponding *cis* salt was prepared from the above by digesting 40 gm. with 100 ml. water on the steam bath for 1 hr., cooling rapidly, and filtering off the sludge which separated after a short time. The latter, after washing with alcohol and ether and drying over sulphuric acid, gave rise to a fine lilac-coloured powder having properties identical with those of the *cis* salt described by Werner[2]. The absorption curve of a 0·01-*M* solution of this product was found to be practically identical over the range 300–740 mμ with that of the mother liquor appropriately diluted, although slow cooling of the undiluted mother liquor results in the deposition of crystals of the *trans* salt over a period of days.

These results show that solutions of relatively pure potassium *cis* dioxalato diaquo chromium (III) can be prepared conveniently from the more readily purified *trans* salt simply by warming solutions of the latter for a few hours before diluting to the desired concentration, isolation of the solid being scarcely necessary for many purposes.

Complex ion $[Cr(H_2O)_2(C_2O_4)_2]^-$	Optical density		Titration data $\mu = 0{\cdot}01$, temp. 8° C.	
	Max. (mμ)	ε (molar)	pK_1	pK_2
trans	416	34·4	7·5	10·5
	555	32·0		
cis	416	68·5	7·5	9·7
	562	51·0		

The molar extinction coefficients at the two optical density maxima on the absorption curves are given in the accompanying table and were determined with the Beckman *DU* spectrophotometer. In the case of the *trans* salt the observations were made in stages, using freshly prepared 0·01-*M* solutions at 8° C. for each stage of the absorption curve, in order to minimize drift errors; but this was not necessary for the *cis* salt, which was optically stable even at elevated temperatures.

The titration constants shown in the table are calculated from titration curves obtained at 8° C. in the same way, using a Cambridge *p*H-meter and glass electrode assembly, the curves being corrected for blank potassium hydroxide titrations carried out on conductivity water under the same conditions of ionic strength and temperature. These 'constants' refer to the acidic dissociation of the water molecules bound to the complex, and are uncorrected for the ionic strength of the solutions. An exact calculation of the relative contribution of the 'electrostatic' and 'rest' effects to the difference $pK_2 - pK_1$, according to the principles discussed by Bjerrum[4], is therefore scarcely justified at this stage. Nevertheless, since *n* is larger for the *trans* ion than for the *cis* isomer, whereas the reverse would hold were the electrostatic effect the principal factor involved, it is clear that considerable differences in electron distribution must exist between the two isomeric forms of the complex ion.

Further investigations are proceeding, and it is hoped to publish a full account elsewhere in due course.

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[1] van Niekerk, J. N., and Schoening, F. R. L., *Nature*, **166**, 108 (1950); *Acta Cryst.*, **4**, 35 (1951).
[2] Werner, A., *Ann. Phys.*, **405**, 261 (1914).
[3] Croft, H., *Phil. Mag.*, **21**, 197 (1842).
[4] Bjerrum, N., *Z. phys. Chem.*, **106**, 219 (1923); *Svensk. Kem. Tid.*, **38**, 2 (1926).

Sugar Chromatography of Mammary Gland Extracts

THE communication from Drs. Caputto and Trucco[1] on "A New Galactose-containing Compound from Mammary Gland" interests us because our own work on lactose synthesis did at one stage give results very similar to those they now report. The interpretation we put upon our results, however, was different from that which they derive from theirs; further, the tentative conclusions we are now tempted to draw from some of our more recent work are also in conflict with the views expressed in their letter.

Our earlier report (see Malpress[2]) showed the presence of a fraction obtained by the direct trichlor-

Chromatographic Analysis of Reducing Substances Present in Extracts from Incubates of Tissues-Slices of Guinea Pig Mammary-Gland

Spot reference	R_G [R_F Spot / R_F Glucose]	Possible equivalent (Caputto and Trucco)	Typical relative spot concentrations			
			Supernatant		Homogenized slice extract	
			No added substrate	Glucose added	No added substrate	Glucose added
I	0·22	*D* and/or *E*	+	+	++++	++++
Lactose	0·55	*B* and *C*	++	>10+	+	++
Glucose	1·00	*A*	+	+	trace	++
IV	1·18			+++		
V	1·33		+	+++		
VI	1·40				trace	++
VII	1·64					trace
VIII	1·85					+

acetic acid extraction of lactating guinea pig and cow tissues, which gave evidence of the liberation of galactose and glucose after acid hydrolysis; it also commented upon the liberation of lactose from a similar preparation after phosphatase action. These preparations were obtained by precipitation with four volumes of ethanol after a preliminary barium–ethanol fractionation of the neutralized trichloracetic acid extract; they contained a slow-moving, low-R_F compound when run in collidine, which we judge, by virtue of its comparable extraction and behaviour on the chromatogram and on hydrolysis, to bear a very close resemblance to the compounds *D* and *E* now discussed by Caputto and Trucco. We also believe it to be identical with spot I (see table) found in our later experiments, which we have summarized below.

At the time of our first report we were inclined to minimize the possible importance of this compound as an intermediate in lactose synthesis, especially since we were not always able to reproduce the evidence of galactose liberation on hydrolysis. It seemed to us that the absorption of minute traces of a galactose or lactose phosphate upon this slow-moving compound could account equally well for the results we were getting. This view has now been made more feasible by the recent identification in this laboratory of α-galactose-1-phosphate as a normal trace constituent of milk: it is clear that in the extracts of lactating mammary tissue used by Caputto and Trucco and by ourselves, galactose-1-phosphate might well have been present and could have played the part of a contaminant.

However, our reluctance to accept a galactose-containing compound of complex tetra- or hexa-saccharide type[1] arises mainly from our more recent work on the chromatographic picture given by incubates of lactating mammary gland tissue from the guinea pig. The results of this work are summarized in the accompanying table, in which the arbitrary values given to spot intensities are based on subjective estimates of the reduced-silver areas produced by the developing method of Trevelyan *et al.*[3] applied to chromatograms run in collidine. The results must be regarded as presenting average findings obtained from a large number of experiments. The supernatants came from 3-hr. incubates of washed and blotted guinea pig mammary slices, either with or without glucose as an added substrate; they were treated with yeast suspensions to remove excess glucose, precipitated with an equal volume of ethanol, and the final, clear solutions worked up for chromatographic analysis. The homogenized slice extracts were obtained by homogenizing the carefully washed slices in water, at the end of the incubation period, filtering the resultant extract through 'Hyflo Supercel' and treating the clear solutions so obtained with alkaline phosphatase before preparing them for analysis. Lactose synthesis from added glucose was demonstrable in these incubates, and we feel that the final solutions offered more reliable material for chromatography than the trichloracetic acid extracts of unwashed milk-containing glands.

Under these conditions we have been able to recognize only one low-R_F compound, which we relate directly to the low-R_F compound present in our trichloracetic acid extracts, and thence, if our earlier reasoning is correct, to either the compound *D* or the compound *E* of Caputto and Trucco. We have found that it is invariably in greater concentration in the tissues than in the supernatant fluid—which might support the contention that it is a compound of polysaccharide type—but it is most resistant to hydrolysis, and after elution from the chromatogram has remained practically unchanged by treatment with *N* hydrochloric acid for one hour at 100° C., the liberation of a trace of glucose being the only effect encountered. We have not been able to detect any action of amylase upon it, while the fact that its concentrations in both supernatants and homogenized slice extracts are undiminished when the tissue is incubated in the absence of glucose substrate, or in the presence of various inhibitors of lactose synthesis (for example, glyceraldehyde, sodium fluoride, sodium azide, iodoacetate) again limits in our opinion the likelihood of its being an important compound in the formation of the disaccharide.

We have no evidence of any lactose 'complex' (Caputto and Trucco's spot *C*) by these methods, but have clear indications of a number of reducing substances, each with an R_F greater than that of glucose (see table), which we think may prove more relevant to the problem of lactose synthesis. We are led to this view primarily by the fact that these substances do show a dependence on the presence of glucose substrate and are affected by inhibitors of lactose synthesis.

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[1] Caputto, R., and Trucco, R., [*Nature*, **169**, 1061 (1952)].
[2] Malpress, F. H., *C.R. du Colloque International sur le mécanisme physiologique de la sécrétion lactée, Strasbourg*, 1950 (in the press).
[3] Trevelyan, W. E., Procter, D. P., and Harrison, J. S., *Nature*, **166**, 444 (1950).

Micro-Chemical Determination of Magnesium, Calcium and Zinc with Disodium Ethylene-diamine Tetra-acetic Acid

Since its original development for use as a water softener in the German textile industry[1], the di-sodium salt of 'Trilon B' (ethylene-diamine tetra-acetic acid) has been developed by Schwartzenbach and associates in the estimation of alkaline earths and other metals[2]. The application of this research to water hardness testing has been fully described in *The Analyst*[3]. The method has now been modified as described below.

(*a*) Using eriochrome schwartz T (Solochrome black) to estimate zinc down to 1·5 μgm. ± 0·5 μgm., and magnesium down to 12 μgm. ± 4 μgm. (providing zinc is present at 1 per cent of magnesium), or ± 8 μgm. magnesium when zinc is absent. Calcium magnesium and zinc cannot be distinguished by the method. *p*H must be about 10.

(*b*) Using ammonium purpurate (murexide) to estimate calcium down to 10 μgm. ± 4 μgm. Any copper present is estimated as calcium. *p*H about 12. Magnesium has no effect.

Method. 5 c.c. (or even 1 c.c.) solution to be tested, of strength between 0·001 *M* and 0·0001 *M*, is run into a 1-in. specimen tube. Add for (*a*) 1 c.c. buffer (N NH_4Cl + N NH_4OH) and 3 drops Solochrome (giving a dilute wine-red colour). Titrate with 0·0001 *M* disodium ethylene-diamine tetra-acetate for zinc, or with 0·0005 *M* ethylene-diamine tetra-acetate for magnesium. The titration is complete when the red colour cannot be seen, and the colour is a pale grey. Extra drops of disodium ethylene-diamine tetra-acetate produce a green colour. As soon as a colour change is seen, 30 seconds should elapse between drops, as the colour develops slowly. Add for (*b*) 1 c.c. *N* sodium hydroxide and 3 drops of saturated ammonium purpurate solution in water, and titrate with 0·001 *M* disodium ethylene-diamine tetra-acetate. The colour change, which is from pink to purple, cannot be seen in artificial light, but is quite sharp in good daylight from a north-facing window.

For stronger solutions, with both dyes the amount of dye must be increased. During the titration an extra 1 ml. of buffer should be added for every 5 ml. disodium ethylene-diamine tetra-acetate added. Impurities in the ammonia should be estimated, using a blank. Slight excess of Solochrome masks the wine-red colour. Although the titrations are reversible with higher concentrations, it is not quite true with the most dilute solutions. A discussion of the utilization of these methods will be published later.

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[1] *Bios*, 421. *Fiat*, 644.
[2] Beldermann and Schwartzenbach, *Chimia*, **2**, 56 (1948).
[3] *Analyst*, 323 (1947).

Dirac's New Theory of the Electron

IN the last section of a recent paper[1], Dirac discusses his formulæ with the following words: "An important feature of the new theory is that it involves only the ratio e/m, not e and m separately. This is what one should expect in a purely classical theory. The existence of e should be looked upon as a quantum effect, and it should appear in a theory only after quantization, and not be a property of classical electrons".

If this point of view be accepted, some properties of electrons which have always been regarded as classical should be regarded as quantum effects; for example, the scattering of long electromagnetic radiation by free electrons. It is well known (see, for example, ref. 2) that the cross-section for scattering, obtained by a purely classical procedure, is:

$$\sigma = \frac{8\pi}{3}\left(\frac{e^2}{mc^2}\right)^2.$$

This does not depend on e/m alone, but on the combination $m\left(\frac{e}{m}\right)^2$. Therefore, the mass of the electron can be obtained by observations the interpretation of which has so far always been regarded as an example of classical theory.

Dirac's formulation of the situation needs, therefore, some comment. I personally think that the appearance of the electronic radius

$$a = \sqrt{\sigma/\pi} = \sqrt{\frac{8}{3}}\,\frac{e^2}{mc^2}$$

as a result of a classical reasoning indicates that the future theory should differ from the present one not only in explaining the integral values of all charges by a quantization, but also in introducing an absolute length right from the beginning. I am further convinced that it is futile to deal with the electron and its electromagnetic field separately, but that the fields of all mesons together with the electromagnetic field should be simultaneously considered. I have indicated a way of doing this elsewhere[3], and though I am far from thinking that this suggestion is right, I am still convinced that the solution must be sought in this direction.

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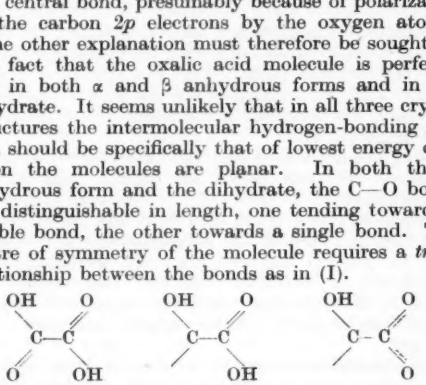
[1] Dirac, P. A. M., *Proc. Roy. Soc.*, **209**, 19 (1951).
[2] Born, M., "Atomic Physics", 324 (5th edit.), Appendix VIII.
[3] Born, M., *Rev. Mod. Phys.*, **21**, 463 (1949).

Evidence for Intramolecular Attraction between Hydroxyl and Carbonyl Oxygen Atoms

THE accurate crystal structure analyses of α-oxalic acid[1] and oxalic acid dihydrate[2] show that the length of the central C—C bond is indistinguishable from the single bond-length of 1·5445 A. in diamond within a probable limit of ± 0·025 A. It is inferred that there is no appreciable degree of π-conjugation across the central bond, presumably because of polarization of the carbon 2*p* electrons by the oxygen atoms; some other explanation must therefore be sought for the fact that the oxalic acid molecule is perfectly flat in both α and β anhydrous forms and in the dihydrate. It seems unlikely that in all three crystal structures the intermolecular hydrogen-bonding system should be specifically that of lowest energy only when the molecules are planar. In both the α anhydrous form and the dihydrate, the C—O bonds are distinguishable in length, one tending towards a double bond, the other towards a single bond. The centre of symmetry of the molecule requires a *trans* relationship between the bonds as in (I).



A similar *trans* planar configuration has been found in the molecules of crystalline tartaric acid[3] and hydrate racemic acid[4]. In both structures the two

crystallographically independent C(OH)COOH halves are planar within the experimental errors of the structure analyses. The tartaric acid analysis is not sufficiently precise to distinguish between the C—O bond-lengths, but the valency angles in this compound and the measurements of both angles and bond-lengths from racemic acid show that the OH groups are *trans* related (II). A similar planar configuration (III) is also found for the tartrate ion in Rochelle salt[5].

Altogether, there are nine independent determinations in which the C(OH)COOH or C(OH)COO— group is planar. The arguments from the van der Waals forces alone are against the planar arrangement, since it contains an oxygen-to-oxygen approach of 2·65 A., which could be extended to 2·95 A. by a rotation about the C—C bond, without decreasing other intramolecular distances to less than that value. These measurements provide a body of experimental evidence which cannot be ignored, and some interaction other than the oxygen-to-oxygen repulsion is necessary to account for it. There can be no possibility of intramolecular bonding through the hydrogen atom as, for example, in salicylic acid[6], for not only would the COH angle be less than 70° but also the rational interpretation of the intermolecular distances in these crystal structures requires the hydrogen bonding to be between the oxygen atoms in adjacent molecules. The simplest interpretation within the framework of present knowledge of forces between non-bonded atoms in the same molecule is that there is, in the crystalline state at least, a significant electrostatic attraction between the hydroxyl and carbonyl oxygen atoms.

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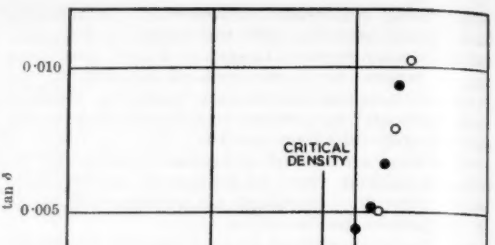
[1] Cox, E. G., Dougill, Marion, and Jeffrey, G. A. (unpublished work).
[2] Ahmed, F., and Cruickshank, D. W. J. (unpublished work).
[3] Stern, F., and Beevers, C. A., *Acta Cryst.*, **3**, 341 (1950).
[4] Parry, G. S., *Acta Cryst.*, **4**, 131 (1951).
[5] Beevers, C. A., and Hughes, W., *Proc. Roy. Soc.*, A, **177**, 251 (1941).
[6] Cochran, W., *Acta Cryst.*, **4**, 376 (1951).

Dielectric Loss in a Polar Gas near its Critical Point

In the course of some measurements of the dielectric polarization of compressed methyl fluoride, we have noticed the appearance of strong dielectric absorption near the critical point. The absorption increases rapidly with the density of the gas and it rises with increasing frequency over the range we investigated (1–5 megacycles).

Using the apparatus described elsewhere[1], we have measured the loss factor at 1 Mc./s. and at the temperatures 50° C. and 75° C. The range of density covered was 0·001–0·012 moles/c.c. and the pressures were between 30 and 120 atmospheres. The critical data for methyl fluoride[2] are: T_c, 44·55° C.; P_c, 58·0 atm.; ρ_c, 0·00883 moles/c.c. Our results are shown in the accompanying graph, where the tangent of the loss angle is plotted against the density of the gas.

A remarkable feature of the results is the suddenness with which the dielectric loss develops as the density of the gas approaches the critical value. The absorption is almost certainly associated with the energy expended in rotating the dipolar molecules and it might be expected to conform to Debye's theory[3]. The bulk viscosity of supercritical methyl fluoride is not known, but that of carbon dioxide[4] shows no singularity at the critical density; if methyl fluoride were to behave similarly, the Debye theory would call for a monotonous variation of tan δ with density. This is obviously not the case.



Dielectric loss of methyl fluoride: ● at 50° C., ○ at 75° C.

A plausible interpretation of the results is that the rapid increase in power loss is brought about by a fairly sharp transition from a state in which the ellipsoidal molecules are rotating freely to one in which they are aligned like cigars in the way that Hirschfelder and his colleagues[5] picture them in the critical state. This sort of change would not necessarily be reflected in the bulk viscosity.

A fuller account of these measurements will be published later.

We wish to thank Dr. J. S. Dryden for his valuable help in this work.

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[1] David, H. G., Hamann, S. D., and Pearse, J. F., *J. Chem. Phys.* (in the press).
[2] Cawood, W., and Patterson, H. S., *J. Chem. Soc.*, 2180 (1932).
[3] Debye, P., "Polar Molecules" (Reinhold, New York, 1929).
[4] Phillips, P., *Proc. Roy. Soc.*, A, **87**, 48 (1912).
[5] Bird, R. B., Spotz, E. L., and Hirschfelder, J. O., *J. Chem. Phys.*, **18**, 1395 (1950).

Isolation of Nitrifying Organisms and Oxygen Supply

In a communication, "Isolation of the Nitrifying Organisms from Soil"[1], Dr. Howard Lees stated that he believed that he obtained a pure culture of *Nitrosomonas* with his percolator method. The only one who, so far, has got a pure culture of *Nitrosomonas* without any microbiological technique has been Bonazzi. Lees ascribes the success of this technique to the good aeration the percolator method provides to the culture. Bonazzi also aerated his cultures, but he hesitates to ascribe his success only to aeration. This experience led Lees to the conclusion that the well-known difficulties encountered in getting pure cultures

of the nitrifiers were due to a lack of oxygen supply. This view he tries to justify by referring to correct figures on oxygen consumption of nitrifying cultures and diffusion-rate of oxygen taken respectively from Stephenson and Höber.

It will be shown here that their application to the problem of getting pure cultures is not justified. The usual rate of nitritation ($2NH_3 \rightarrow N_2O_3$) in the static enrichment cultures is that 50 mgm. ammonium sulphate is oxidized in seven days. If diffusion alone is to supply oxygen, it would be necessary that all the bacteria should be present during the last 12 hr. of the culture in a layer of 1 mm. thickness at the surface of the culture. This could only be accomplished by swarming bacteria; but experience shows that this is not the case. Oxygen supply is therefore not by diffusion alone, but also by convection currents. This is not surprising, because in the incubators the bottoms of the culture flasks are heated and the surface of the culture liquid cools by evaporation, so there will be currents going up and down. Moreover, it can be shown that the rate of oxidation can be increased by adding a second portion of 50 mgm. ammonium sulphate at the end of the period of seven days. After this, the oxidation is completed in four days. It is therefore certain that, in enrichments to be used for plating, the nitrifying organisms never suffer from lack of oxygen. This was confirmed by the fact that in shaken cultures the rate of oxidation was usually the same as in the static cultures. Sometimes there was a slight acceleration by shaking, but this may have been due to the prevention of formation of zoogloea. The heterotrophic bacteria, however, are also stimulated by shaking, so that this is no improvement. This is to be expected, because an increase of autotrophic bacteria means more food for the heterotrophic bacteria, and therefore it seems very improbable that pure cultures will be obtained from enrichments by any method that will stimulate the growth of nitrifiers.

It is a fact that *Nitrosomonas* is stimulated by some metabolic products of the heterotrophic bacteria, for when *Nitrosomonas* is in a pure culture its growth is at first very slow. If the growth-rate of the enrichments were only determined by the oxygen supply, it would be expected that pure cultures would grow at least as rapidly as enrichments. It looks as if the heterotrophic bacteria produce some growth-factor for *Nitrosomonas* which is not strictly necessary or which they can learn to make themselves, for after some time the nitrification-rate becomes normal. The nitrification-rate of pure cultures is also accelerated by *Nährstoff*-Heyden[2]. This shows that the growth-rate of *Nitrosomonas* is not conditioned by the respiration process but by the assimilation process. As the minimum generation time of the nitrifying bacteria is about 5–6 hr., it is clear that in cultures inoculated with a small number of bacteria the nitrification-rate will always appear to be very slow, notwithstanding the nitrification-rate per bacterium is optimal.

It should be pointed out that for plating one needs only cultures with 100–500 bacteria per ml., hence it is quite unnecessary to have cultures with a high nitrification-rate with millions of bacteria per ml.

Dr. Lees's remarks about the amount of growth in Petri dishes are not correct. In the first place, the growth is not limited by the air space, but by the amount of ammonium sulphate. The capacity of a Petri dish of diameter 10 cm. and height 1·5 cm. is about 117 ml. Filling it with 25 ml. silica gel leaves an air space of 90 ml., which contains 18 ml. oxygen. In the gel there is 25 mgm. ammonium sulphate, for the oxidation of which 12·7 ml. oxygen is required, so there is plenty of oxygen. In the second place, a Petri dish is anything but closed. In the daytime the temperature in the incubators will fluctuate more or less, because they are often opened and closed and therefore there will be some replacement of air in the dish. Further, fresh air will be sucked in when oxygen is removed by the bacteria. To this may be added that Meyerhof found that the respiration-rate is first affected when the oxygen tension is lowered to half the tension of the oxygen of the air.

From all this it is clear that the problem of getting pure cultures[3] is not one of oxygen supply, and that it is very unlikely that the percolator method will give as a rule a pure culture. Notwithstanding this, the percolator method may be useful for obtaining nitrifying bacteria in quantities that otherwise would be difficult to get.

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[1] Lees, H., *Nature*, **167**, 355 (1951).
[2] Kingma Boltjes, T. Y., *Arch. Mikrob.*, **6**, 79 (1935). Hes, J. W., *Rec. Tr. Bot. néerlandais*, **34**, 234 (1937).
[3] Hanks, J. H., and Weintraub, R. L., *J. Bact.*, **32**, 653 (1936). Meiklejohn, J., *J. Gen. Microb.*, **4**, 185 (1950).

In the communication referred to by Prof. Kingma Boltjes, I was dealing explicitly with intensive nitrification. Prof. Kingma Boltjes, on the other hand, is considering rather low nitrification-rates, at which oxygen supply will be naturally less important. I therefore do not think that our respective calculations are exactly comparable.

I am, however, glad to have the opportunity of agreeing wholeheartedly with his remarks about the possible importance of growth-factors in the economy of *Nitrosomonas*; our own experiences have led us to suspect that one such factor may be biotin.

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Biochemical Role of Vitamin C

The interesting communication by Kalnenas[1] on the amounts of ascorbic acid in the plasmas of antarctic birds and mammals contains a statement that ought not to go unchallenged. He says, "Ascorbic acid is an indispensable hydrogen carrier in the metabolism of animals". Contrast this with the more realistic statement of Harris[2], "It has to be admitted . . . that the exact biochemical role of vitamin C is still obscure, although there is probably significance in the recent findings that in animal tissues it can catalyse the oxidation of the side chain of the . . . tyrosine".

Again, Damron *et al.*[3] have studied the *in vivo* oxidation of ascorbic acid to dehydroascorbic acid and then to diketogulonic acid and interpret their results to suggest that these reactions "represent pathways of decomposition rather than of normal metabolism in animal tissues".

Kalnenas is surely arguing in a circle. Only the primates and the guinea pig, so far as is known, cannot synthesize their requirements of vitamin C, as he correctly states; yet in all animals hitherto

investigated, the vitamin is found in the plasma and other tissues. Because it is always present it is assumed to be essential, and because it is an oxidation reduction catalyst it is described as "an indispensable hydrogen carrier in the metabolism of animals". It is surely not wise to disguise our ignorance about a fundamental metabolic problem by making sweeping and unsupported statements. Our knowledge is likely to be increased only by an accumulation of precisely the kind of facts given in Kalnenas's own letter.

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[1] *Nature*, **169**, 836 (1952).
[2] Harris, L. J., "Vitamins: A Digest of Current Knowledge" (Churchill, Ltd., London, 1951).
[3] Damron, C. M., Monier, M. M., and Roe, J. H., *J. Biol. Chem.*, **195**, 599 (1952).

A Simple Rotating-Cell Double-Beam Unit for Spectrometers

Since publishing our preliminary report on this unit[1], we have been able to carry out further tests upon materials having strong absorption bands in the region of atmospheric water vapour absorption. From these experiments, we have now found that our system is not a true double-beam system, since it measures the difference between the energies of the two beams, and not their ratio. Consequently the absorption due to atmospheric water vapour and carbon dioxide is not completely removed, but appears as a function of the absorption of the test material at these wave-lengths.

Polystyrene sheet was chosen as our first test material for ease of manipulation. This choice was particularly unfortunate, since the wave-lengths of the strong absorption bands of this material do not fall near those of strong water-vapour absorption. It is for this reason, together with the low resolution used in our preliminary experiments, that the effects of atmospheric water-vapour absorption are not apparent in our published spectrum.

Brown, Holliday and Trotter[2] have pointed out to us that our rotating-cell system is really an 'inverted' single-beam system with a variable 100 per cent absorption line. They have also brought to our notice that an analogous principle was suggested some years ago by Hilger and Watts, Ltd., for the alignment of the entrance and exit slits of their *D*.209 double-beam spectrometer. In this method, the two thermocouple detectors are connected in opposition. If the slits are correctly aligned, no signal is observed when passing through a region of atmospheric water-vapour absorption. When a sample is introduced into one beam, however, the record gives the absorption spectrum of the sample minus the water-vapour absorption: the stronger the absorption band of the sample, the greater the amount of water-vapour absorption subtracted.

One advantage of our system is that it can be used for the investigation of weak sample bands in the region of atmospheric water-vapour absorption when it is not possible to eliminate the water absorption beyond a few per cent of the total energy. Residual water absorption of this magnitude would be negligible for weak sample absorption and, consequently, weak bands could be identified with certainty. With this in view, a method similar in principle to, but simpler than our rotating cell, can be used for the examination of solid films[3]. In this method, portions of the specimen are attached to the circumference of a disk mounted in place of the conventional chopping sector.

Our method also enables the strong aliphatic CH-band due to the 'Nujol' used in mulls to be reduced considerably by using a 'Nujol' film in the blank cell. This reduction in intensity of aliphatic CH-bands enables the aromatic CH-bands of substances under investigation to be more clearly identified.

We would like to apologize to any workers who may have started to construct a rotating-cell system on the basis of our earlier communication. In these circumstances, it is not proposed to publish further details of the mechanism used for rotating the cells.

J. D. S. Goulden
S. S. Randall

Research Department,
Biochemistry Division,
Boots Pure Drug Co., Ltd.,
Nottingham.
May 26.

[1] Goulden, J. D. S., and Randall, S. S., *Nature*, **169**, 748 (1952).
[2] Brown, L., Holliday, P., and Trotter, I. F. (private communication).

Production of Electric Charges on Water Drops

A recent communication[1] by Gill and Alfrey implies that we have interpreted the potential differences accompanying the freezing of dilute aqueous solutions as contact potentials. On the contrary, we agree with Gill and Alfrey that "a contact potential difference of 230 volts seems most unlikely". We further believe that the implied interpretation is completely untenable, because the observed potential differences cause the flow of *currents* of the order of 1 μamp. The statement in question is that "the potential barrier is at the water-ice interface". This statement was intended to convey that the charge separation occurs at the interface, and that each ion involved in the charge separation must cross a potential-barrier equal in magnitude and sign to the measured potential difference between the ice and water.

Gill and Alfrey suggest that certain impurities in the water might reverse the sign of the potential differences as distilled water is frozen. We believe that our experiments[2] show clearly that the sign and magnitude of the potential difference developed and the quantity of charge separated during freezing are functions of the kind and amount of contaminants in solution with the water. It was only after recognition of these facts that we were able to escape the irreproducibility that apparently plagued Gill and Alfrey in their experiments, and our conclusion that the potential differences result from the selective incorporation of foreign ions into the growing ice structure is based in part on these facts.

It is suggested by Gill and Alfrey that the potential differences arise because the surface charges which cause the contact potential difference between ice and water are continuously frozen into the ice. They state that "the reverse process does not appear to take place when melting occurs, for the much higher conductivity of water would prohibit the building up of a volume distribution of charge in the water". It should be pointed out that, in an experiment such as they describe, both ice and water are present whether freezing or melting is going on. The con-

ductivity of the water should be nearly the same in either case, and therefore should not preclude the operation of the process in the case of melting. If, however, in accordance with their mechanism, the positive charges on the growing ice surface were furnished by the water, there would seem to be no reason for presuming such a reverse potential. In the case of melting, this charge would merely be returned to the water as opposed to being incorporated in the ice during freezing.

Gill and Alfrey state that a potential of sign opposite to that observed during freezing was observed during melting and that this opposite potential "was due to positive charges in the ice which had not time to leak completely away before melting commenced, and which entered the water as the ice melted. (There had been a slight leakage over the insulators of the negative charge in the water.)". The situation described would result in a reversal of current at the ice-water interface but would not, of course, result in the described reversal of sign of the potential difference. As we have stated[2], the potential difference is often reversed during the solidification of doubly distilled water without added impurities (the principal contaminant in the water probably becomes different as freezing progresses because the ice incorporates or rejects different impurities to different extents). Since it would be difficult, in the experiment described, to determine whether freezing or melting was going on at the interface, we believe it is likely that the reversed potentials thought to accompany melting actually occurred while freezing was still going on.

Our discussion[2] of the applications to meteorology of the electrical phenomena accompanying freezing is quite parallel to that of Gill and Alfrey, except that we were able to point out that the usually observed contaminants in rain water collected aloft cause a 'freezing potential' which would result in a thunderstorm of the usually observed polarity.

E. J. Workman
S. E. Reynolds

New Mexico Institute of Mining and Technology,
Socorro, New Mexico.
April 21.

[1] *Nature*, **169**, 203 (1952).
[2] *Phys. Rev.*, **78**, 254.

The main point at issue occurs in the first paragraph. It is whether or not there is an abrupt potential change at the surface, whatever name it be called—contact potential or potential barrier. The original statement by Workman and Reynolds that the potential barrier is at the water-ice interface means in the ordinary use of language that the potential change, which may be more than 100 volts, is a complete discontinuity there, or at best is spread over a distance of a few molecular diameters, involving an electric force of millions of volts a centimetre. The expanded statement seems to imply much the same.

We, on the other hand, think this voltage is produced by a volume density of charged ions frozen into the ice. The voltage change is spread over several millimetres and the electric force is reasonable. In addition, the fresh ions do not have to cross this large potential barrier (and it is difficult to see how they could) but increase it by being frozen on the outside.

We entirely agree that the phenomenon is not due to the water, but to what is dissolved in it.

Experiments done with a variety of solutions did prove that charge was frozen into the outer layers because, if the outside of the ice, which was formed around a central metal rod, was gradually melted off by immersion in warm water, a positive charge could be measured continually arriving in the water until a few millimetres had thawed off, when it ceased.

The suggestion of Workman and Reynolds that the results of a somewhat similar experiment with distilled water described in our original communication were due to a mixture of impurities, and that freezing was continuing when we imagined melting was taking place, cannot possibly explain these latest results.

E. W. B. Gill

Merton College,
Oxford.

A Sensitive Method for the Detection of Traces of Water in Oil

Correspondents have pointed out that the derivation of the expression for the wetness of an oil in terms of the manometer reading, as given in the communication under this title in *Nature* of March 8, p. 412, is probably incorrect.

A close examination has been made of all the test results obtained. An incorrect value was used for the density of acetylene used in calculating wetness by the carbide test. The values for the water content of the oils quoted have therefore been recalculated[1] and are as follows:

OM 13	(*a*)	0·0057 per cent
	(*b*)	0·0076 " "
OM 35		0·012 " "
Castor oil *BP*	(*a*)	0·079 " "
	(*b*)	0·086 " "

These values are of the same order of magnitude as those commonly accepted for 'clear and bright' oils containing water in solution. The humidiscope readings are in wide disagreement with these values, but until further theoretical investigation is completed (in collaboration with correspondents) the reason for this must be left in abeyance.

Examination of the humidiscope readings obtained for emulsions appears to show that a relation holds of the form

$$p^2 \propto w,$$

where p is manometer reading, w is water percentage added to dry oil. Suggestions as to possible implications would be welcome.

My apologies are due to readers who may have endeavoured to use the equation given in my original communication; at the moment, the use of the instrument can be recommended only where facilities for making emulsions of known water content for calibration purposes are available; continuous re-circulation through a high-speed gear-pump for 20 min. is satisfactory.

J. E. C. Stringer

Experimental Oil Test Group,
Research Department,
Vickers-Armstrongs, Ltd.,
Elswick Works,
Newcastle upon Tyne 4.
May 6.

[1] Based on the value $d_{0.760} = 1{\cdot}173$ mgm./ml., from Esbach, O. W., "Handbook of Engineering Fundamentals" (1946).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, June 30

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. D. L. Drabkin: Features in the Metabolism of the Chromoproteins".*

Wednesday, July 2

CEMENT AND CONCRETE ASSOCIATION (at the Royal Institute of British Architects, 66 Portland Place, London, W.1), at 2.30 p.m.—Symposium on "Concrete Shell Roof Construction" (The Architectural Aspect of Concrete Shell Roofs).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. D. L. Drabkin: "Newer View-points in Biological Regulation".*

Thursday, July 3

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. Edward Elliott: "Psychological Theories of Learning and Problems of Industrial Training".

Thursday, July 3—Friday, July 4

CEMENT AND CONCRETE ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1).—Symposium on "Concrete Sheet Roof Construction" (Thursday, at 9.30 a.m.: Design and Research; Friday, at 9.45 a.m.: Construction and Formwork).

Thursday, July 3—Saturday, July 5

INSTITUTE OF PHYSICS, INDUSTRIAL RADIOLOGY GROUP (at Crewe Hall, The University, Sheffield).—Summer Meeting.

Friday, July 4

BRITISH MYCOLOGICAL SOCIETY (at the Hawthorndale Laboratories of Imperial Chemical Industries, Ltd., Jealott's Hill, Bracknell, Berks), at 10.30 a.m.—Annual Plant Pathology Field Day.

Saturday, July 5

INSTITUTE OF PHYSICS. EDUCATION GROUP (in the Science Lecture Theatre, Christ's Hospital, Horsham), at 10.45 a.m.—Summer Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD OF THE DEPARTMENT OF INDUSTRIAL ENGINEERING, Acton Technical College—The Chief Education Officer (F/CW), Middlesex County Council, 10 Great George Street, London, S.W.1 (July 4).

PHYSICISTS at a Ministry of Supply Research Establishment at Aldermaston, Berks: SCIENTIFIC OFFICERS (3) (Ref. A.172/52A) for research on methods of measurement of radiations; for one post a knowledge of counting equipment and D.C. amplifiers for ionization chambers is required. SCIENTIFIC OFFICERS (2) (Ref. A.173/52A) for investigational work on properties of and special methods of handling radioactive materials, EXPERIMENTAL OFFICERS (4) (Ref. A.174/52A) to assist in the duties of the officers outlined above—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (July 5).

ANALYST (Experimental Officer grade) for soils, crops and fertilizers in the Chemistry Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 7).

LECTURER IN DAIRYING—The Registrar, The University, Reading (July 7).

BIOCHEMIST in the Veterinary Research Division of the Ministry of Agriculture, Belfast—The Secretary, Civil Service Commission, Stormont, Belfast (July 8).

ASSISTANT LECTURER IN ELECTRICAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (July 10).

PLANT PHYSIOLOGIST (Scientific Officer grade) (with a good honours degree in botany or agricultural botany) at the Agricultural Research Council's Unit of Plant Nutrition at Long Ashton Research Station, Bristol—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (July 10).

ASSISTANT LECTURER IN GEOGRAPHY (with qualifications and interest in historical geography)—The Secretary, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2 (July 11).

SENIOR RESEARCH OFFICER (Chemist or Chemical Engineer) (with University honours degree in science, with chemistry as major subject, or in chemical engineering, with some industrial experience, preferably in research and development) in the Wool Textile Research Laboratory, Geelong, Vic., to establish a section for research into certain processes of the textile industry, particularly felting and scouring—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3880 (July 19).

PHYSICIST (with an honours science degree and hospital experience in medical physics) to work mainly at the Main National Cancer Centre in Dublin—The Secretary, Comhlachas Ailse na h-Eireann (Cancer Association of Ireland), Oakland, Highfield Road, Rathgar, Dublin (July 21).

PRINCIPAL SCIENTIFIC OFFICER, R.A.F. Acoustics Laboratory, London—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4151/52 (July 24).

LECTURER IN THE DEPARTMENT OF PSYCHOLOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Cape Town, July 31).

ASSISTANT LECTURER IN STATISTICS, and an ASSISTANT LECTURER IN ECONOMICS—The Secretary and Registrar, The University, Southampton.

CIVIL ENGINEERS in the Colonial Engineering Service in Hong Kong, Malaya, Sarawak and North Borneo—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27322/B.

DEMONSTRATOR IN PHYSICS—The Registrar, The University, Nottingham.

DEPUTY CHIEF SCIENTIFIC OFFICER to be Head of the Theoretical Physics Division at the Atomic Energy Research Establishment, Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.179/52A.

FOREST BOTANIST (with good honours degree in botany and at least three years postgraduate experience, preferably in taxonomy), North Borneo, for work in connexion with re-establishment and expansion of herbarium at Sandakan—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27040/90.

JUNIOR LECTURER IN PHYSICS at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

LECTURER (Grade B) IN PHYSIOLOGY—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

PHYSICIST (with university degree, general or special physics, or equivalent professional examination) for research on the physical properties of materials for use in scientific instruments—The British Scientific Instrument Research Association, Sira, Southill, Chislehurst, Kent.

PHYSICIST (Senior Experimental Officer grade) in the Division of Atomic Energy (Production), Research and Development Branch, Culcheth, Warrington, to undertake experimental work in the application of physical methods to the study of metals and to the development of methods of control of new metallurgical processes—The Establishments Branch, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 333.

PRINCIPAL METALLURGIST in the Division of Atomic Energy (Production), Research and Development Branch, Springfields Factory, Salwick, Preston, to direct teams engaged on industrial metallurgical processes such as melting, casting, powder metallurgy and fabrication, or in studying the physical metallurgy of such processes—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 327.

PRINCIPAL PHYSICIST (Principal Scientific Officer grade) in the Division of Atomic Energy (Production), Research and Development Branch, Culcheth, Warrington, to be responsible for the research work of a physics laboratory, applying physical methods to the study of metals and to the development of methods of control of new metallurgical processes—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 331.

PROFESSORSHIPS IN THE FACULTY OF MECHANICAL ENGINEERING (1), FACULTY OF ARCHITECTURE AND TOWN PLANNING (1), FACULTY OF SCIENCE (2, Division of Experimental Physics, and Division of Physical Chemistry), DEPARTMENT OF CHEMICAL ENGINEERING (2), and DEPARTMENT OF AERONAUTICAL ENGINEERING (3, Aeroplane Structures and Dynamics (2), and Metallurgy); ASSOCIATE PROFESSORSHIPS IN THE FACULTY OF CIVIL ENGINEERING (2, Division of Geodesy and Surveying, and Division of Hydraulics), FACULTY OF ELECTRICAL ENGINEERING (2, Division of Power Engineering (Electric Machinery), and Division of Electronics and Telecommunications); SENIOR LECTURERS IN THE FACULTY OF CIVIL ENGINEERING (2, Division of Structural Engineering, and Division of Hydraulics), FACULTY OF MECHANICAL ENGINEERING (1, Division of Tools, Machinery, and Factory Lay-out), FACULTY OF SCIENCE (2, Division of Physics, and 3, Division of Mechanics), Hebrew Institute of Technology, Haifa, Israel—The Secretary, Technion Society of Great Britain, 13 Mansfield Street, London, W.1.

RADIO ENGINEER (with good academic qualifications, a sound knowledge of electronics, and practical experience) for duties in connexion with the maintenance and development of radio aids to marine navigation—The Secretary, Northern Lighthouse Board, 84 George Street, Edinburgh.

RESEARCH ASSISTANT (graduate in biochemistry or chemistry) to work on problems associated with the sprue syndrome and other nutritional disorders—Prof. A. C. Frazer, Department of Pharmacology, The University, Birmingham.

SENIOR CHEMIST in the Division of Atomic Energy (Production), Research and Development Branch, Culcheth, Warrington, to undertake research work on corrosion, electro-chemistry, thermo-chemistry, surface chemistry and constitution of alloys—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 332.

SENIOR PHYSICIST and PHYSICIST in the Division of Atomic Energy (Production) at Capenhurst Factory, Chester, to be responsible for and to participate in the work of a section of physicists and engineers doing research on mass transfer problems involving change of state, development of special gas analysis techniques, research into and development of dynamic vacuum techniques and equipment, and research on problems concerning fluid dynamics—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 345.

STATISTICIANS (with a first- or second-class honours degree in statistics or in mathematics, economics or other appropriate main subjects combined with statistics) in the Colonial Service—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.